Moriond Results from DØ

Andrei Nomerotski (Fermilab) for DØ collaboration

Wine & Cheese 3/26/2004
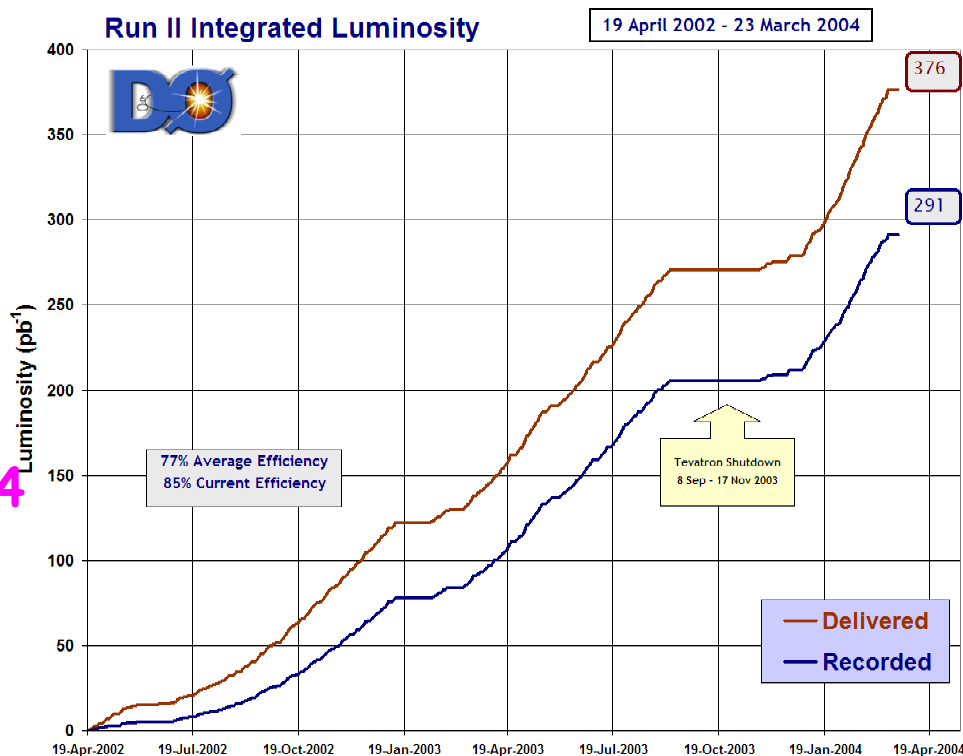
- **This talk covers analyses presented at Moriond 2004 on**
  - **B Physics**
  - **New Phenomena searches**
- **A lot of exciting new results!**

- **Current datasets**

  ~300 pb^{-1} on tape

  ~200 pb^{-1} analyzed

  ~100 pb^{-1} Run I

Status

- **Excellent performance of Accelerator Division in 2004 – THANK YOU!**

  - **DØ recorded 70 pb⁻¹ in 2004**

Run II Integrated Luminosity

19 April 2002 - 23 March 2004

376

291

77% Average Efficiency
85% Current Efficiency

Tevatron Shutdown
8 Sep - 17 Nov 2003

— Delivered
— Recorded

- **Important milestone : reprocessed full dataset in Fall 2003**

  - **Greatly improved tracking performance**

  - **Good fraction processed off-site**

  - **Analyses shown today use up to 250 pb⁻¹**

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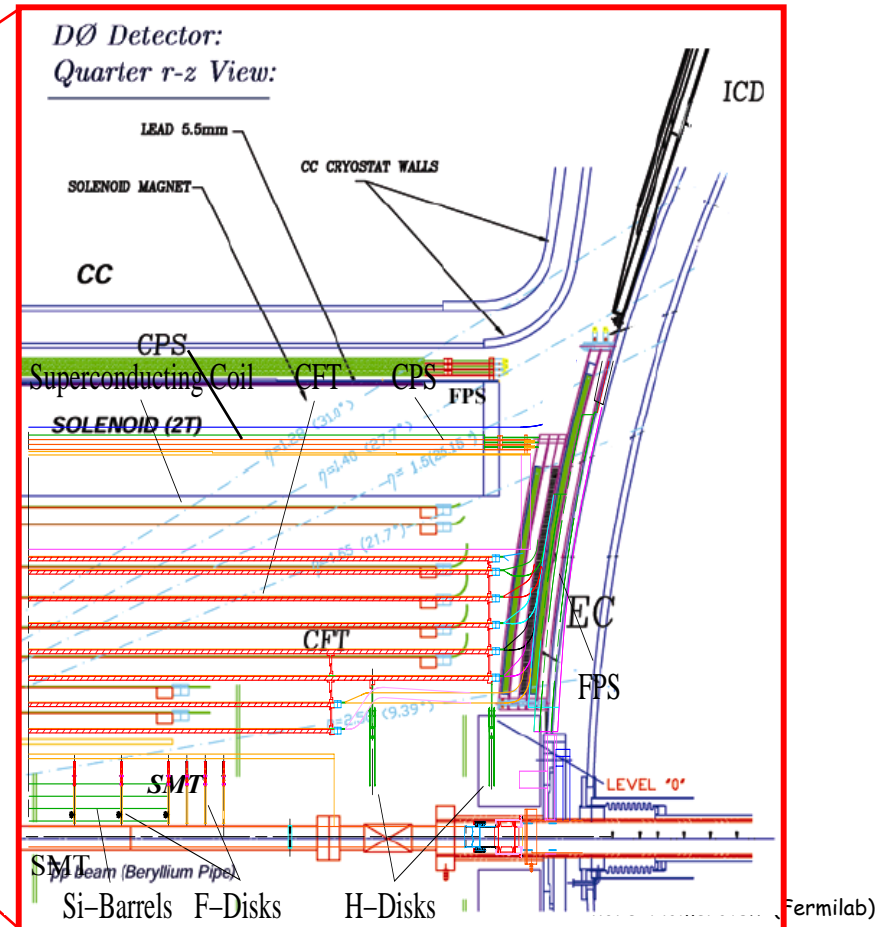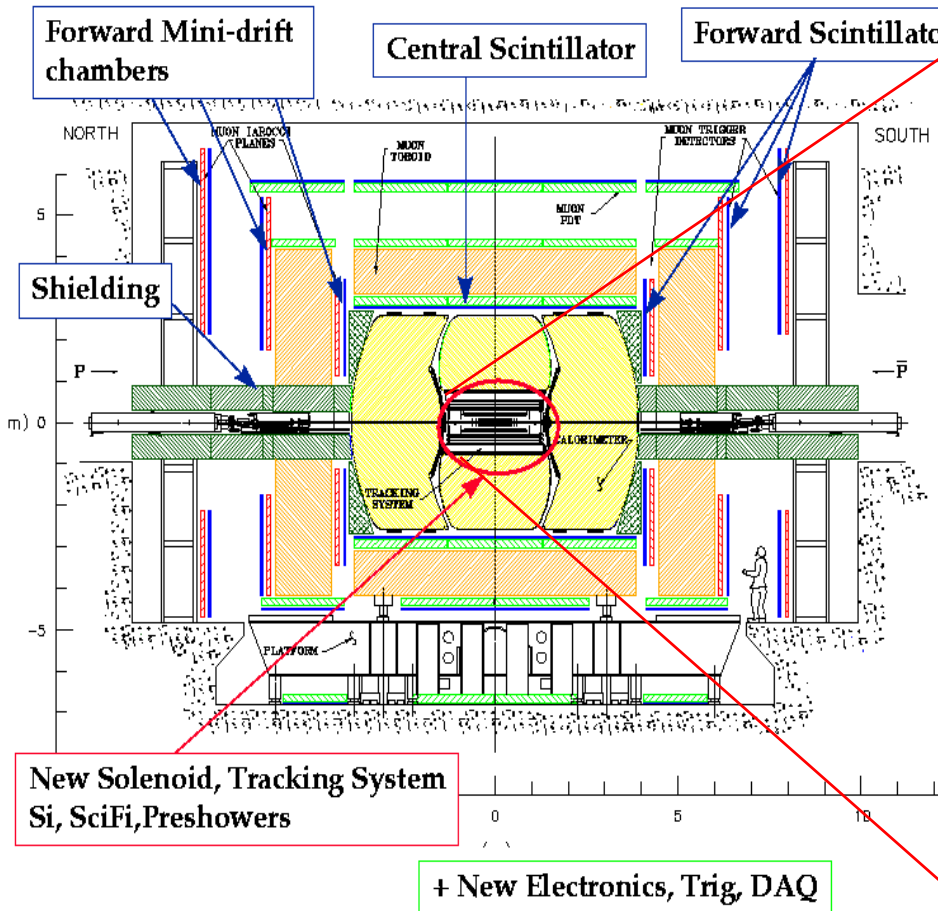Andrei Nomerotski (Fermilab)

B Physics

- **Will present here**

    - Measurement of Lifetime Ratio for B^0 and B^+ Mesons
    - Flavor Oscillations in B_d Mesons with Opposite Side Muon Tagging
    - Observation of Semileptonic B decays to Narrow D** Mesons
    - Observation of X(3872) at DØ
    - Sensitivity Analysis of Rare Bs®mm Decays

- **Key for DØ B-physics program :
  Successful combination of 3 main components**

    - Muon system
    - Tracker
    - Muon trigger

3

Muon System and Tracker

- **New forward muon system with |η|<2 and good shielding**
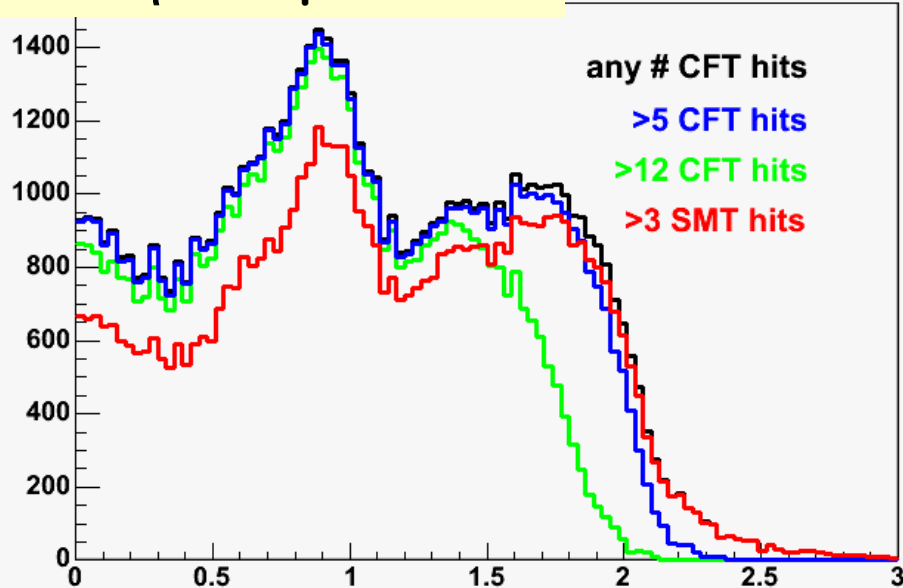- **4-layer Silicon and 16-layer Fiber Trackers in 2 T magnetic field**

Forward Mini-drift chambers

Central Scintillator

Forward Scintillator

Shielding

NORTH

SOUTH

New Solenoid, Tracking System Si, SciFi, Preshowers

+ New Electronics, Trig, DAQ

DØ Detector: Quarter r-z View:

ICD

LEAD 5.5mm

CC CRYOSTAT WALLS

SOLENOID MAGNET

CC

CPS

Superconducting Coil   CFT   CPS

FPS

SOLENOID (2T)

CFT

EC

FPS

LEVEL '0'

SMT

Si-Barrels   F-Disks   H-Disks

SMT

Triggers for B physics

- **Robust and quiet single- and di-muon triggers**
  - **Large coverage $|\eta|$<2**
  - **Variety of triggers based on**
    - **L1 Muon & L1 CTT (Fiber Tracker)**
    - **L2 & L3 filters**

- **Typical total rates at medium luminosity (40 10^{30} $s^{-1}cm^{-2}$)**
  - **Di-muons :   50 Hz /   15 Hz / 4 Hz @ L1/L2/L3**
  - **Single muons : 120 Hz / 100 Hz / 50 Hz @ L1/L2/L3**
    - **Rates before prescaling: typically single muon triggers are prescaled or/and used with raised p_T threshold at L1**
    - **Muon purity 90% - all physics!**
  - **Current total trigger bandwidth**
      1600 Hz / 800 Hz / 60 Hz @ L1/L2/L3

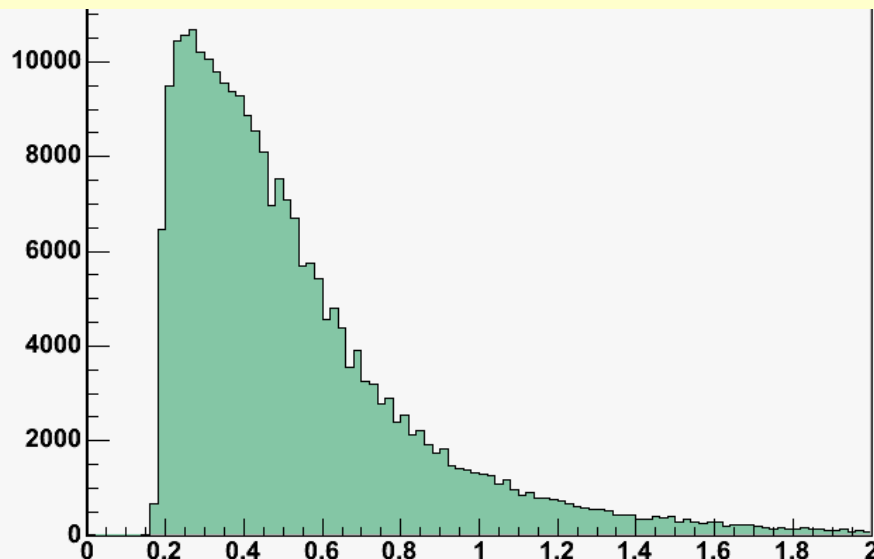- **B-physics semi-muonic yields are limited by L3 filters and L3 bandwidth**

Tracking Performance

p_T spectrum of soft pion candidate in $D^* \rightarrow D^0 \pi$

Muon η in J/psi events

any # CFT hits
>5 CFT hits
>12 CFT hits
>3 SMT hits

Coverage of Muon system is matched by L3/offline tracking

Tracks are reconstructed starting from p_T = 180 MeV

This greatly enhances our B-physics program

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Tracking Performance

Impact Parameter Resolution

★ D0 data (preliminary)
▲ D0 MC single muons

SMT dE/dx

D0 RunII Preliminary
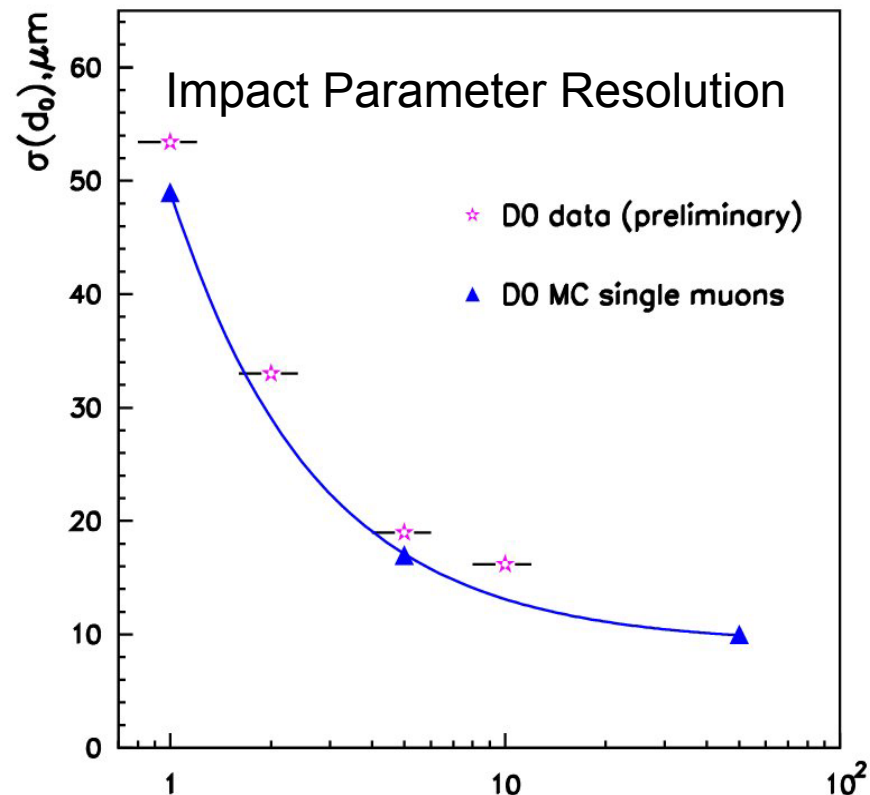
NOT yet used for PID

- $\sigma(DCA) \approx 16~\mu m$ @ P_T = 10 GeV
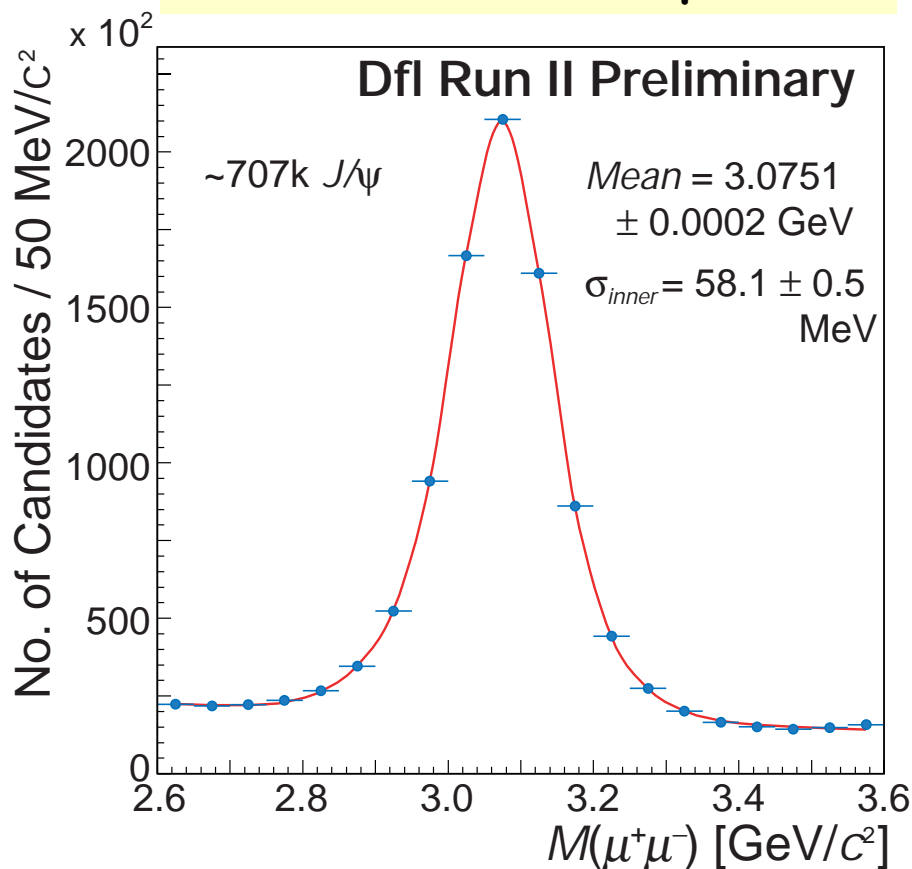 $\sigma(DCA) \approx 54~\mu m$ @ P_T = 1 GeV
- Resolution compares well with MC
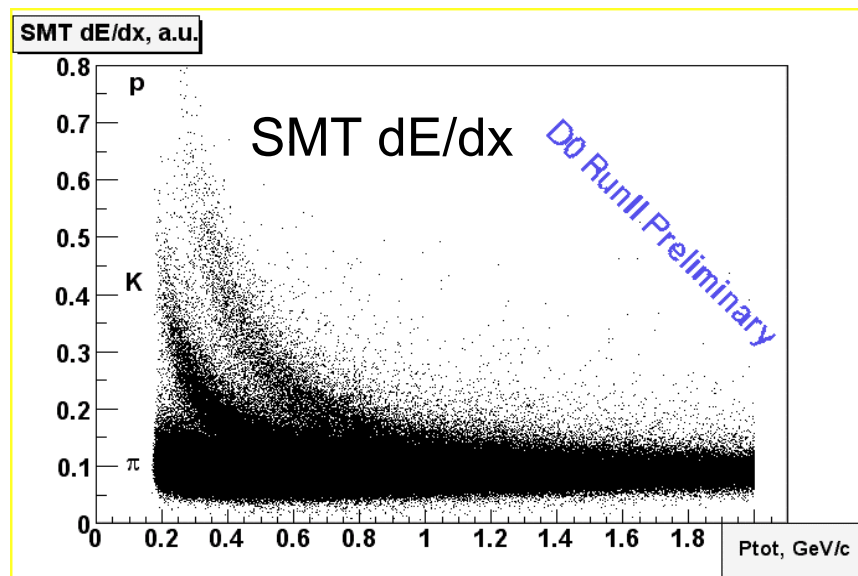
More tracking improvements under way

Calibrations using J/ψ sample

Large J/ψ sample – currently 1.2 M events in 250 pb^{-1}

Dfl Run II Preliminary

~707k J/ψ

Mean = 3.0751 ± 0.0002 GeV

σ_{inner} = 58.1 ± 0.5 MeV

No. of Candidates / 50 MeV/c^2

x 10^2

$M(\mu^+\mu^-)$ [GeV/c^2]

Mass resolution 60 MeV/c^2 in agreement with expectations

J/psi Mass with pT

After magnetic field and material corrections

Mass of J/psi [GeV]

PDG

Before corrections

pT of J/psi [GeV]
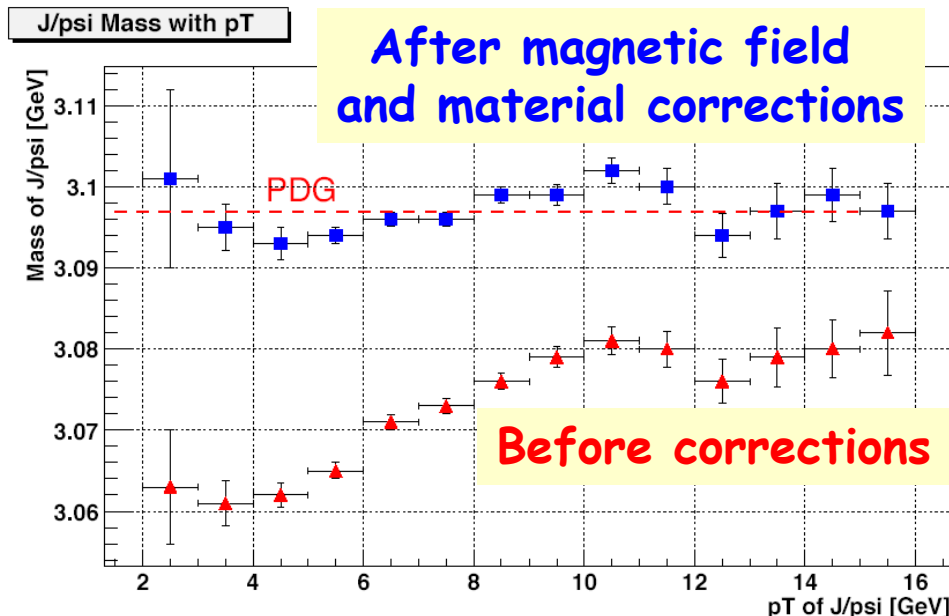
- J/ψ mass is shifted by 22 MeV
- Observe dependence on Pt and on material crossed by tracks
- Developed correction procedure based on field & material model
- Finalizing calibration of momentum scale using J/ψ, Ks, D^0

NOT yet used

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Exclusive B Decays

- **Accumulated large exclusive samples of B⁺ and B⁰**

  Find in 250 pb⁻¹:

  B⁺→ J/ψ K⁺ 4300 events

  B⁰→ J/ψ K* 1900 events

  B⁰→ J/ψ K$_s$ 375 events

  Λ$_b$→ J/ψ Λ   52 events

  - ◆ **Good S/B**
    - ▲ **Lifetime cuts applied**

D0 RunII preliminary.

$B^+ \rightarrow J/\psi + K^+$

$N = 4306 \pm 89$

Ixy/σ(Ixy)>4.5

DØ Run II Preliminary
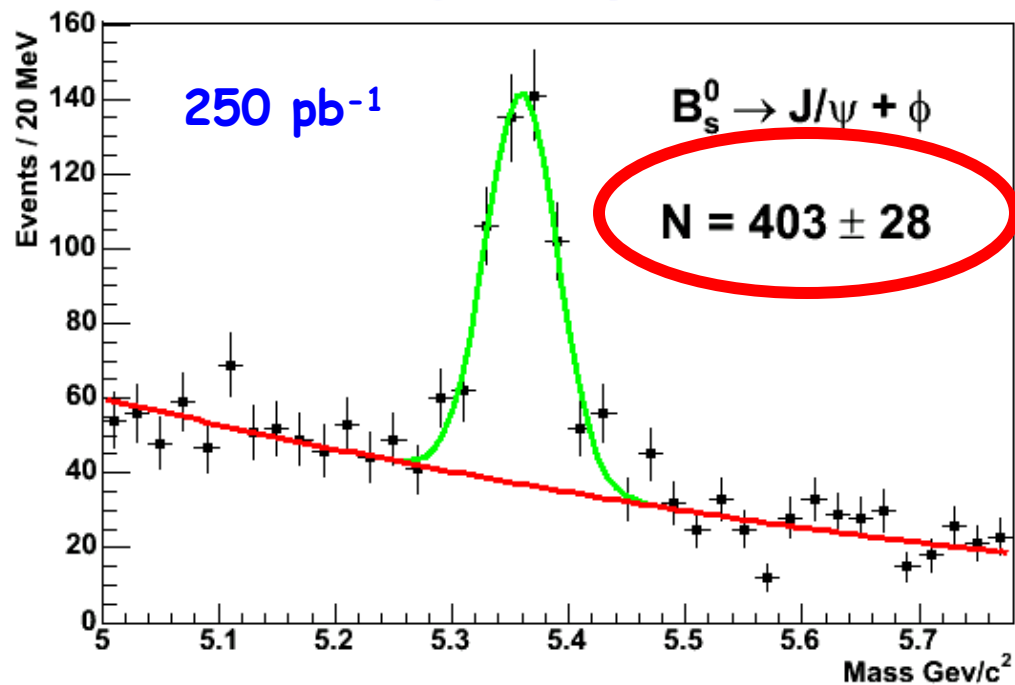
$B_d^0 \rightarrow J/\psi + K_s^0$

$N = 375 \pm 29$
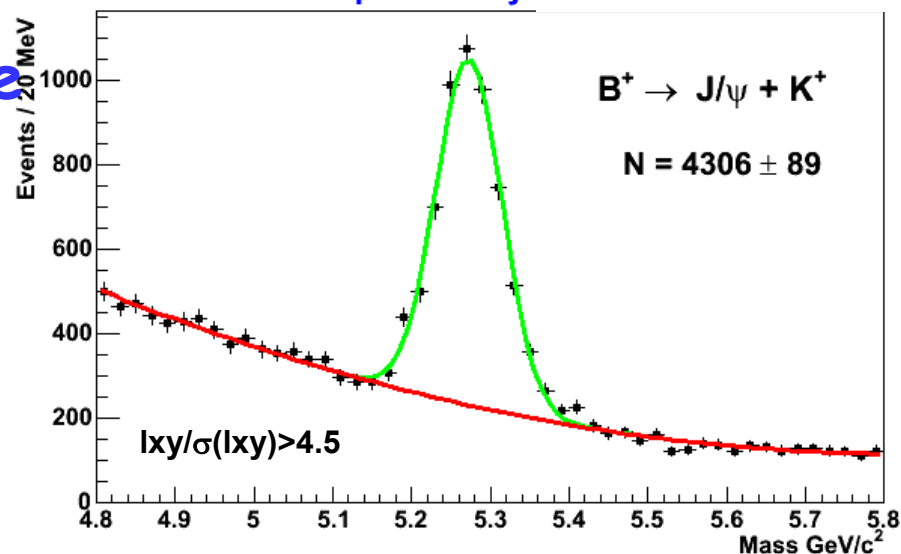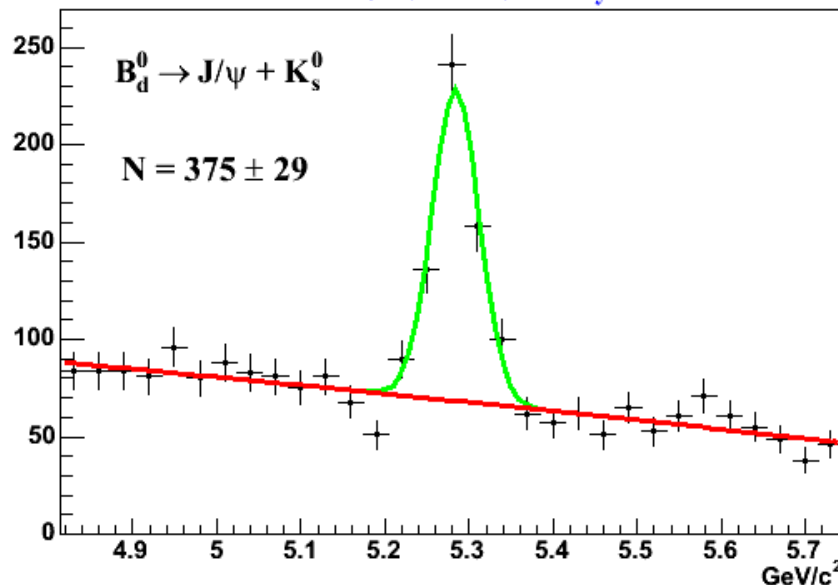
Exclusive B$_s$ Sample

DØ accumulated the world largest sample of exclusive

$$B_s \rightarrow J/\psi \, \phi \, (\rightarrow K^+ K^-) \text{ decays}$$

Some lifetime cuts applied

D0 RunII preliminary.

- 250 pb^{-1}

$B_s^0 \rightarrow J/\psi + \phi$

N = 403 ± 28

(Plot: Events / 20 MeV vs Mass Gev/c^2)

- **We have good potential in all B → J/ψ exclusive modes, work in progress on**
  - ◆ Lifetime measurement of different B species
  - ◆ Studies of CP effects in B$_s$ & B$_d$ mesons

Semileptonic B$_d$ sample

- **Collected by low p$_T$ single muon triggers**
- **109k B$\rightarrow \mu \, \nu \, D^0$ candidates**
- **25k B$\rightarrow \mu \, \nu \, D^*$ candidates**
  - **D* yield 50% higher for looser selections**
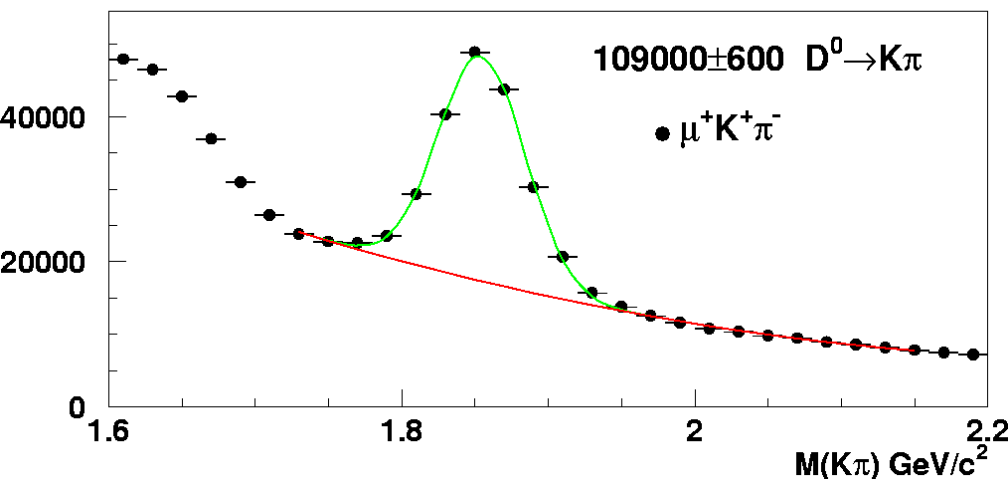- **Plots below have (offline) lifetime cuts**

$$B \rightarrow \mu \, \nu \, D^0 \, X$$
$$\searrow K^+ \pi^-$$
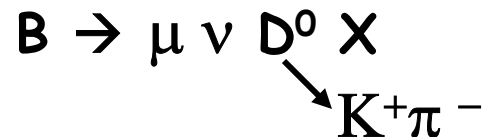
Sample compositions:

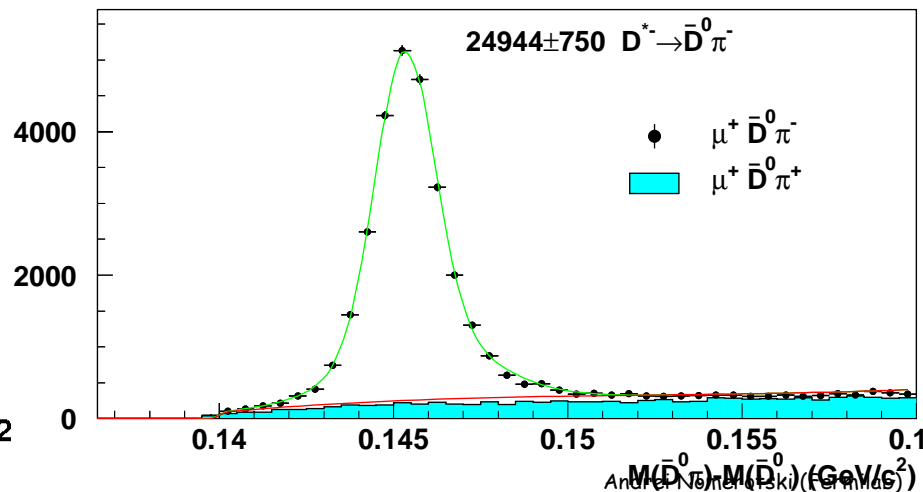"D^0 sample": 82% from B$^+$
"D* sample": 86% from B^0

Estimates based on measured branching fractions and isospin relations.

DØ RunII Preliminary, Luminosity=250 pb^{-1}

109000±600 D$^0 \rightarrow K\pi$

• $\mu^+ K^+ \pi^-$

M(Kπ) GeV/c^2

DØ RunII Preliminary, Luminosity = 250 pb^{-1}

24944±750 D$^{*-} \rightarrow \bar{D}^0 \pi^-$

• $\mu^+ \bar{D}^0 \pi^-$
▪ $\mu^+ \bar{D}^0 \pi^+$

M($\bar{D}^0 \pi$)-M($\bar{D}^0$) (GeV/c^2)

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$\tau(B^+)/\tau(B^0)$ from Semileptonic Decays

Novel Analysis Technique

- **Measure directly ratio of lifetimes instead of measuring absolute lifetimes**

  - **Group events into 8 bins of Visible Proper Decay Length (VPDL):**

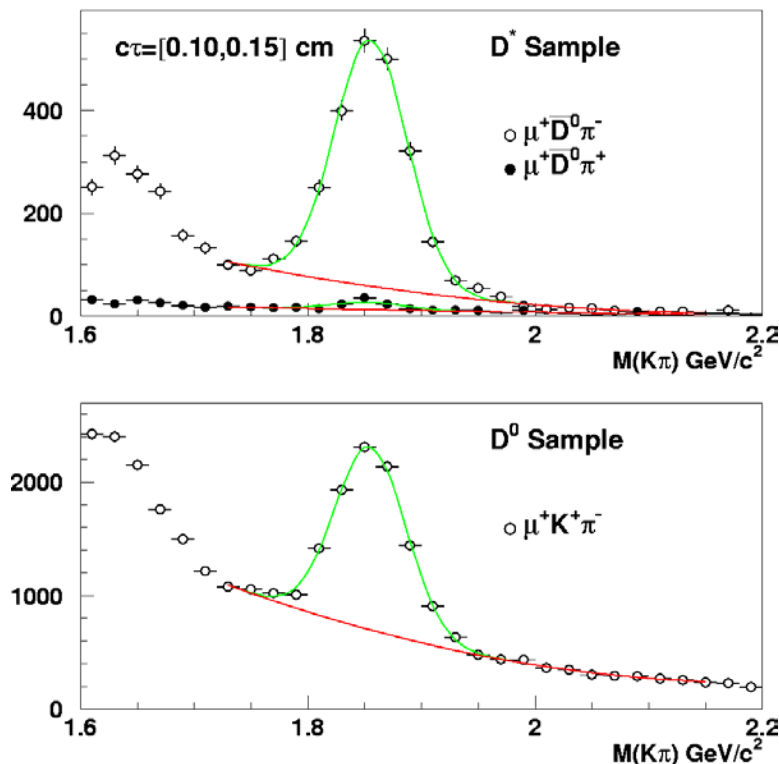 | $VPDL = L_T / p_T(\mu\, D^0) \cdot M_B$ | L_T = transverse decay length |
    |---|---|

  - **Measure $r = N(\mu\, D^*)/N(\mu\, D^0)$ in each bin**
    - **In both cases fit D^0 signal to extract $N(\mu\, D)$**

- **If relative D^*/D^0 efficiency does not depend on VPDL it does not affect the lifetime ratio =>**

  - **Reconstruct slow pion from D^* without biasing lifetime**
    - **Only requirement on slow pion is to give correct $m(D^*)-m(D^0)$ value**
    - **Slow pion is NOT used for calculation of VPDL**
          NOT used in B-vertex
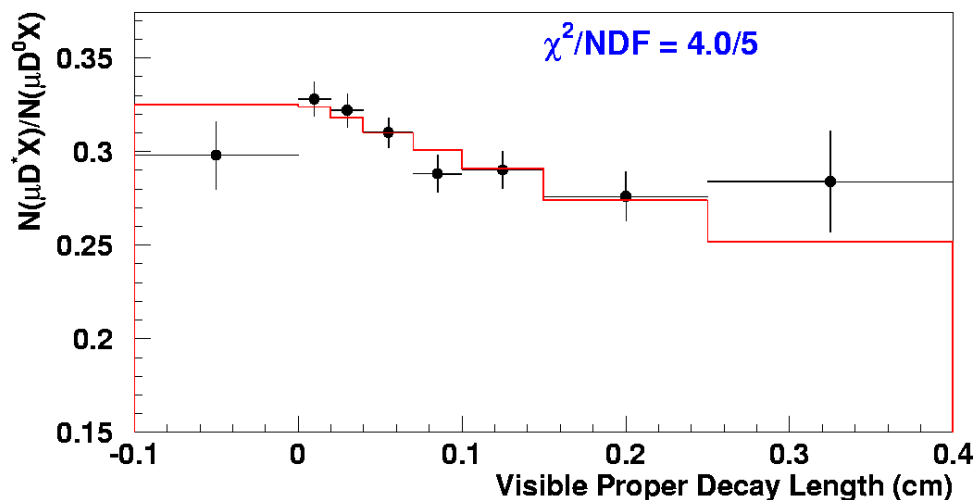   **NOT used in k-factors**

$\tau(B^+)/\tau(B^0)$: Result

one example : VPDL bin [0.10 - 0.15 cm]

DØ RunII Preliminary, Luminosity=250 pb^{-1}

D* Sample

$c\tau = [0.10, 0.15]$ cm

$\circ\ \mu^+\overline{D}^0\pi^-$
$\bullet\ \mu^+\overline{D}^0\pi^+$

M(Kπ) GeV/c^2

D^0 Sample

$\circ\ \mu^+K^+\pi^-$

M(Kπ) GeV/c^2

Use binned χ^2 fit of event ratios to determine $\tau(B^+)/\tau(B^0)$

DØ RunII Preliminary, Luminosity = 250 pb^{-1}

χ^2/NDF = 4.0/5

N(μD*X)/N(μD^{0}X)

Visible Proper Decay Length (cm)

Preliminary result:

$$\tau(B^+)/\tau(B^0) = 1.093 \pm 0.021 \text{ (stat)} \pm 0.022 \text{ (syst)}$$

$\tau(B^+)/\tau(B^0)$

Systematics dominated currently by:

 - time dependence of slow pion reconstruction efficiency
  - relative reconstruction efficiencies
  - Br($B^+ \to \mu^+ \nu D^{*-} \pi^+ X$)
  - K-factors
  - decay length resolution differences $D^0 \leftrightarrow D^*$

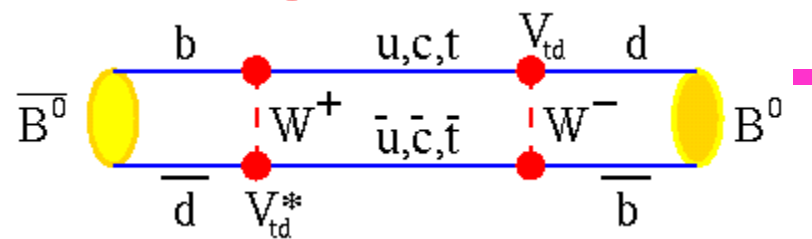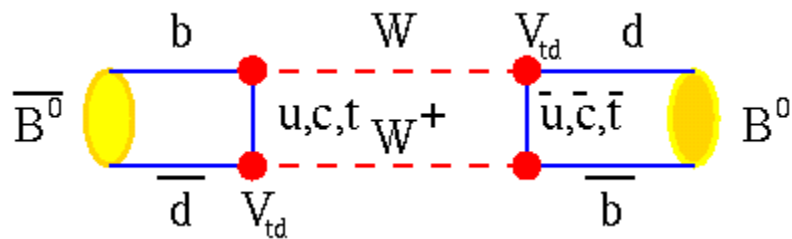**Work in progress to decrease the error**

← **New DØ result**
(average not updated, plot not official or approved by HFAG)

**This is one of the most precise measurements to date**

$B^0/\overline{B^0}$ mixing

- **In SM B_d mixing is explained by box diagrams**
  - ◆ **Constrains V_{td} CKM matrix element**
  - ◆ **Mixing frequency Δm_d has been measured with high precision at B factories (0.502 ± 0.007 ps^{-1})**

- **We use our large sample of semileptonic B_d decays to measure Δm_d**
  - ◆ **Benchmark the initial state flavor tagging for later use in B_s and Δm_s measurements**
  - ◆ **Can also constrain more exotic models of b production at hadron colliders**
    - ▲ light gluino & sbottom production (Berger *et al.*, Phys.Rev.Lett.86,4231(2001))
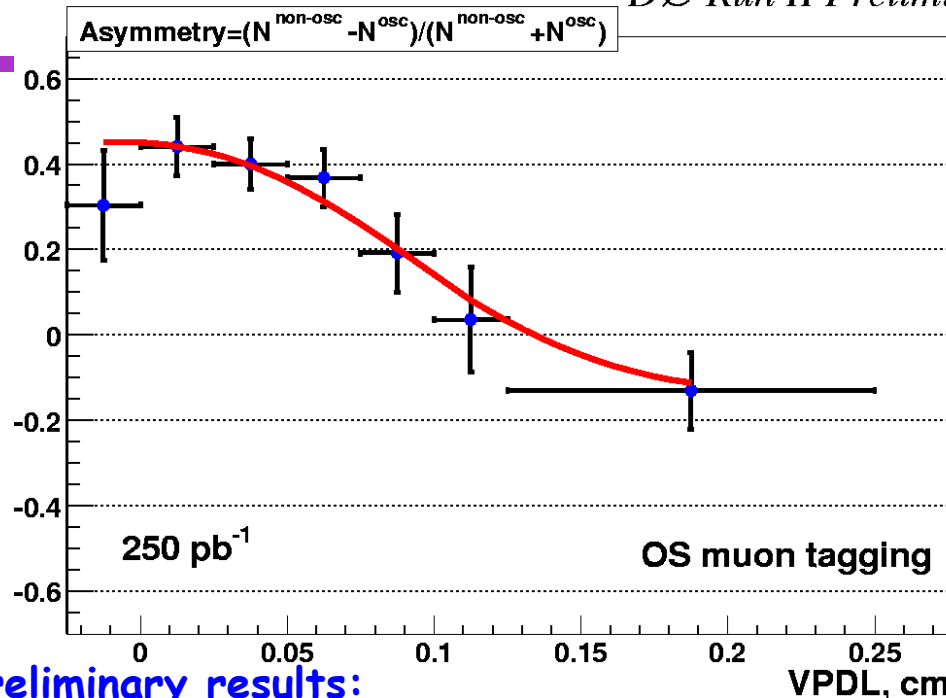
$B^0/\bar{B}^0$ Mixing: Milestone !

B^0

μ
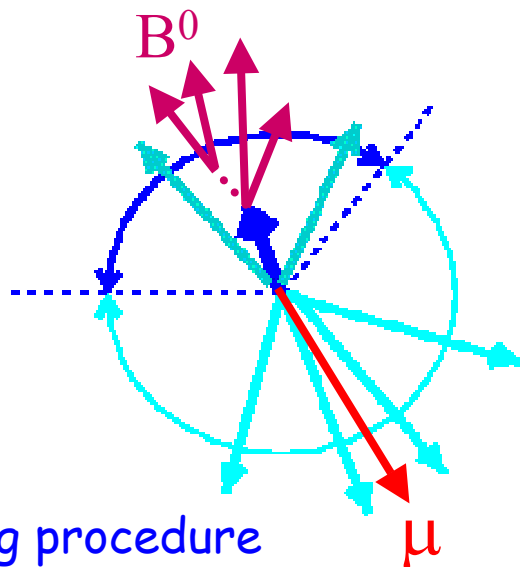
Tagging procedure
- opposite side tight muon
- muon p_T > 2.5 GeV/c
- $\cos \Delta\phi(\mu, B)$ < 0.5

Fit procedure
- Binned χ^2 fit

Asymmetry = $(N^{non-osc} - N^{osc})/(N^{non-osc} + N^{osc})$

250 pb^{-1}

OS muon tagging

VPDL, cm

Preliminary results:

Δm_d = 0.506 ± 0.055(stat) ± 0.049(syst) ps^{-1}

Tagging efficiency: 4.8 +/- 0.2 %
Tagging purity: 73.0 +/- 2.1 %

- **Already one of the best measurements at hadron collider**
- **Good prospects to improve accuracy**
  - **work in progress to decrease systematic uncertainty**
  - **use other tagging methods**
  - **add more D^0 decay channels**

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Observation of B → μ ν D** X

- **D** are orbitally excited D meson states, see diagram**
- **In heavy quark limit expect two sets of doublet states**
  - **Two broad (decay through S-wave)**
  - **Two narrow (decay through D-wave)**
- **Narrow D****
  - $D^0_1(2420) \rightarrow D^{*+} \pi^-$
  - $D^{*0}_2(2460) \rightarrow D^{*+} \pi^-$
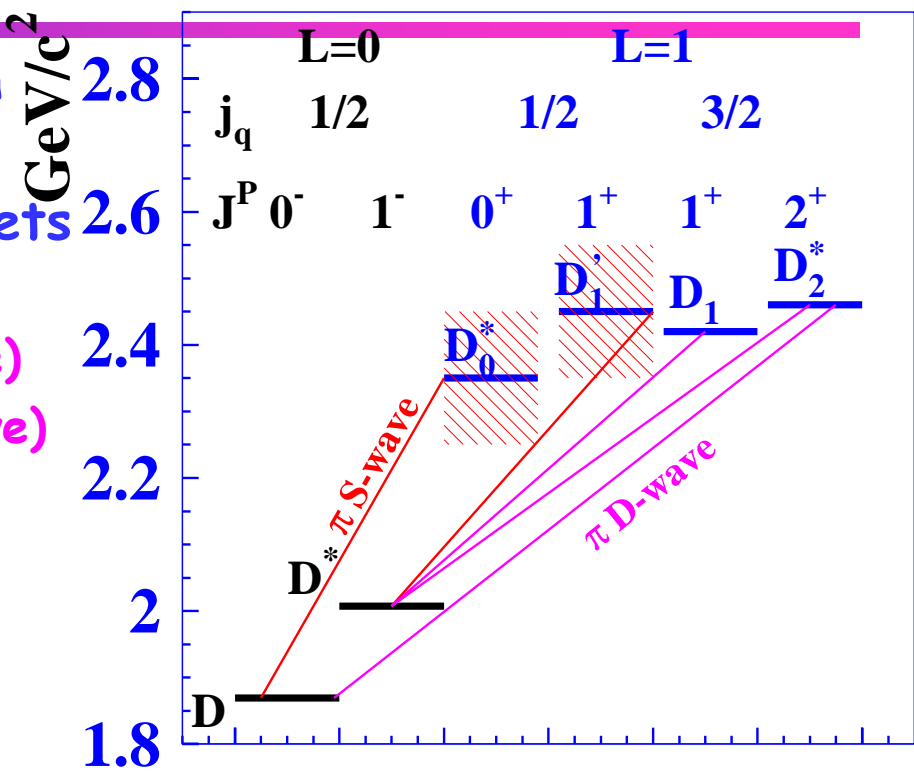   - **One of decay channels**

D_1^0, D_2^{*0} have been observed and studied in several experiments, most recently by BaBar and Belle in $B^- \rightarrow D^{**0} \pi^-$

We study D_1^0, D_2^{*0} produced in semileptonic B decays.

Figure from Belle, hep-ex/0307021

Observation of B → μ ν D** X

- **Start from B → μνD*X sample, add another π⁺**
- **Look at invariant mass of D*⁻ π⁺ system**
- **Observed merged $D_1^0(2420)$ and $D_2^{*0}(2460)$**

D*⁻π⁺ invariant mass

D∅ Run II Preliminary

$$B \to \mu \nu (D_1^0, D_2^{*0}) X \to \mu \nu D^{*-} \pi^+ X$$

250 pb⁻¹   523 ± 40 candidates

Events / 0.01 GeV/c²

wrong-sign combinations

$M_{D^{*-}\pi^+}$ (GeV/c²)

Interfering Resonances
(equal amplitudes)

φ = 0 deg
φ = 90 deg
φ = -90 deg

Invariant Mass [MeV]
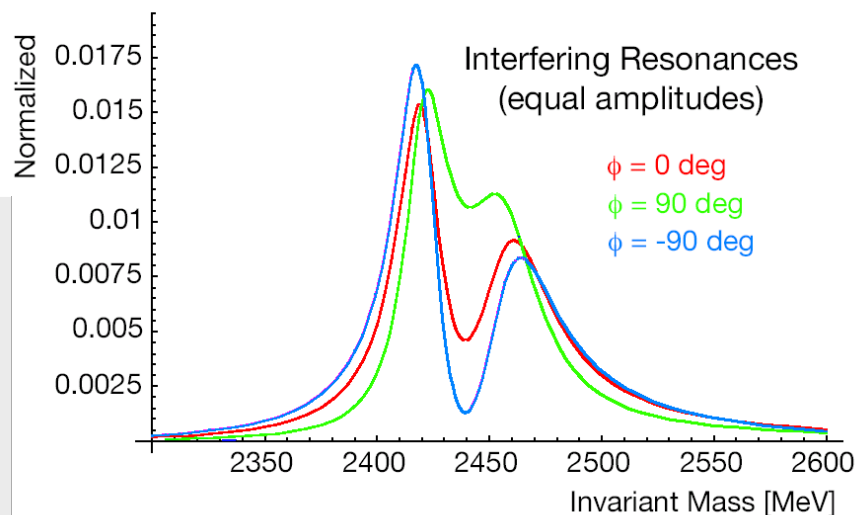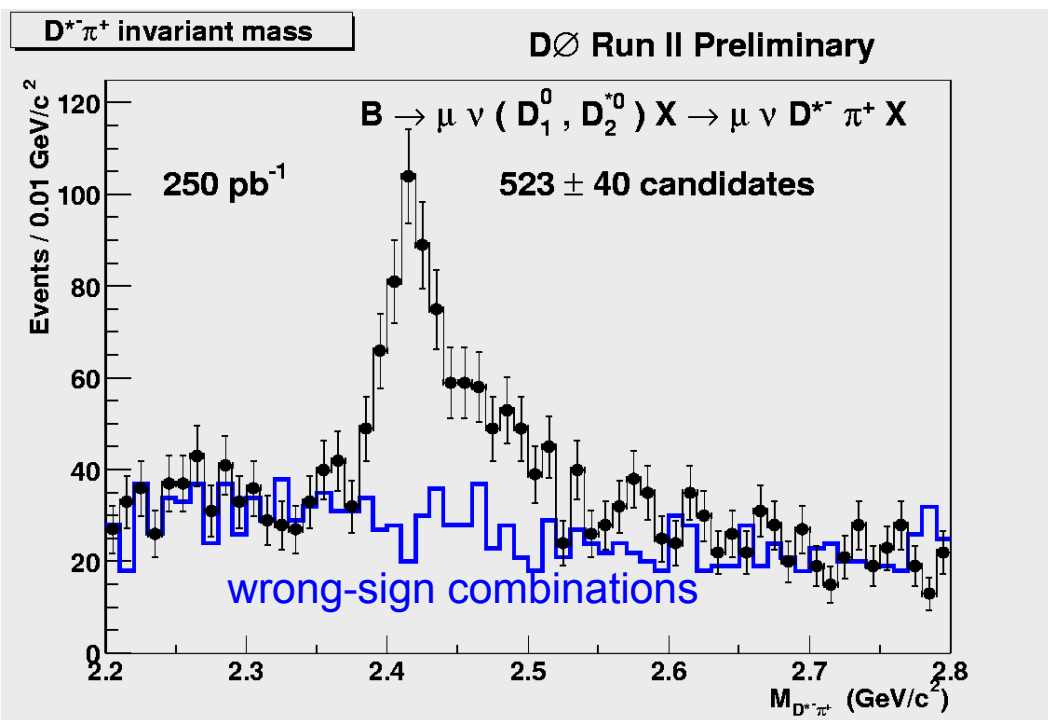
Two interfering Breit-Wigner D states with mass/width as measured by Belle (no resolution effects included)**

Work in progress: extract separate amplitude for each state and relative phase of interference

Unique observation at hadron collider

Preliminary result on product branching ratio

Br(B → {D_1^0,D_2^{*0}} μ ν X) · Br({D_1^0,D_2^{*0}} → D*⁺ π⁻) = 0.280 ± 0.021 (stat) ± 0.088 (syst) %
measured by normalizing to known Br (B → D*⁺ μ ν X)

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B_s semileptonic decays

$$B_s \rightarrow \mu \, \nu \, D_s$$
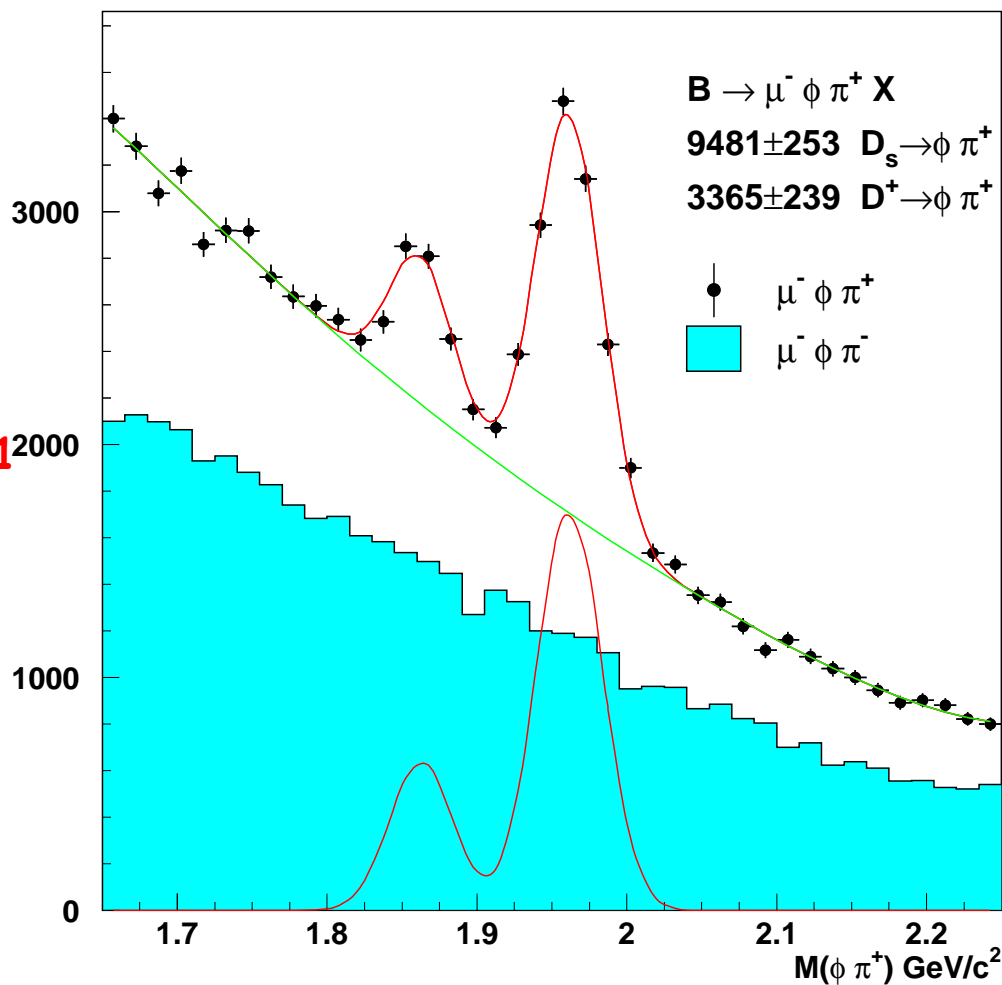$$\hookrightarrow \phi \, \pi$$
$$\hookrightarrow K^+ K^-$$

- Excellent yield :

9500 candidates in 250 pb^{-1}

- $\phi\pi$ invariant mass plot :
some lifetime cuts applied

Work in progress to measure
- B_s/B_d lifetime ratio
- first results on B_s mixing
  - need to fully understand time resolution
  - if $\Delta m_s \cong 15$ ps^{-1} expect a measurement with 500 pb^{-1}

$B \rightarrow \mu^- \phi \pi^+ X$

9481 ± 253 $D_s \rightarrow \phi \pi^+$

3365 ± 239 $D^+ \rightarrow \phi \pi^+$

$\mu^- \phi \pi^+$

$\mu^- \phi \pi^-$

M($\phi \pi^+$) GeV/c^2

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X(3872) → J/Ψ π⁺ π⁻

Last summer, Belle announced a new particle at $\cong 3872$ MeV/c^2, observed in B^+ decays:

$B^+ \to K^+$ X(3872),

  X(3872) $\to$ J/Ψ $\pi^+ \pi^-$

Belle's discovery has been confirmed by CDF and DØ.

DØ preliminary:

300 ± 61 events

4.4σ effect

ΔM = 0.768 ± 0.004 (stat) ± 0.004 (syst) GeV/c^2

DØ Run II Preliminary
200 pb⁻¹

No. of Candidates / 10 MeV/c^2 vs. $M(\mu^+\mu^-\pi^+\pi^-) - M(\mu^+\mu^-)$ [GeV/c^2]
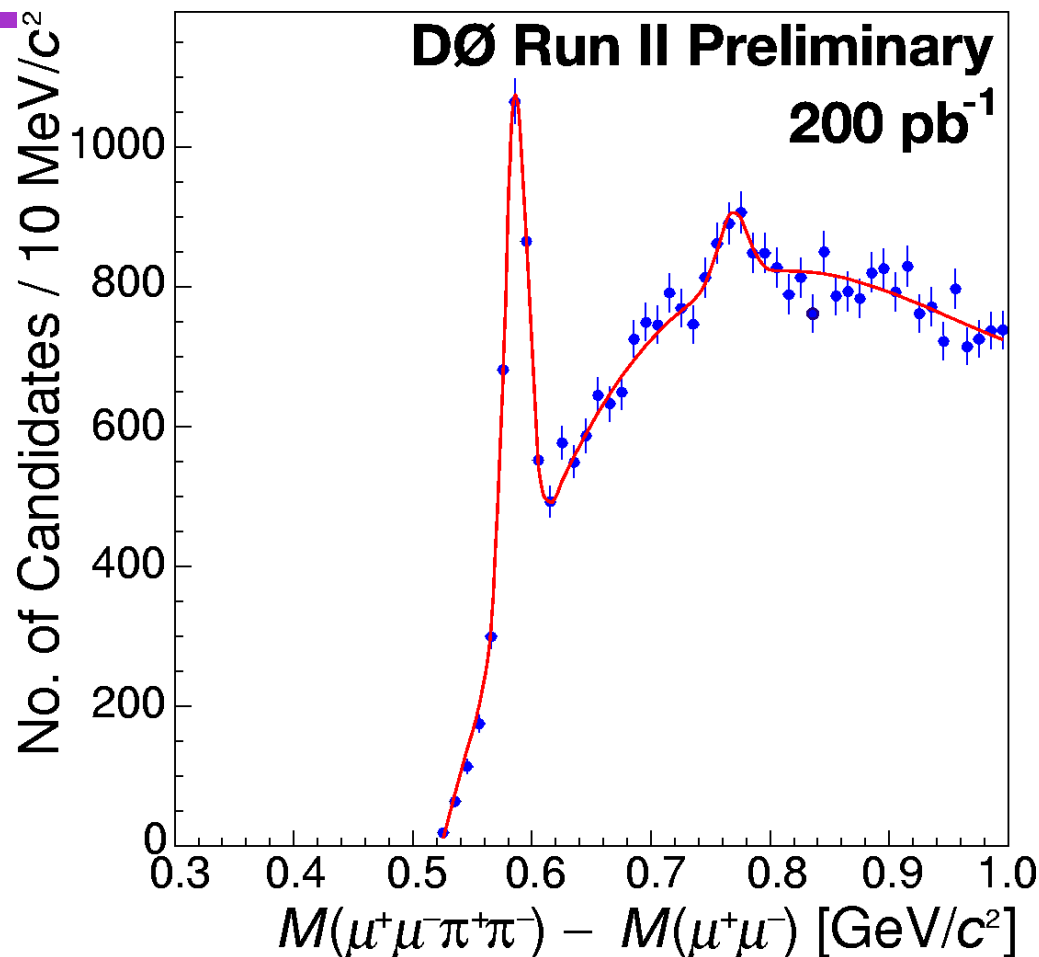
X(3872) production properties

- **Nature of X(3872) is not known**
  - **could be charmonium, meson molecule etc.**
- **Compared sample of X particles to sample of $\Psi(2S)$**

DØ Run II Preliminary

DØ Run II Preliminary

200 pb^{-1}

$\psi(2S)$

$X(3872)$

$|\eta| < 1.0$

$1.0 < |\eta| < 2.0$

$M(\mu^+\mu^-\pi^+\pi^-) - M(\mu^+\mu^-)$ [GeV/c^2]
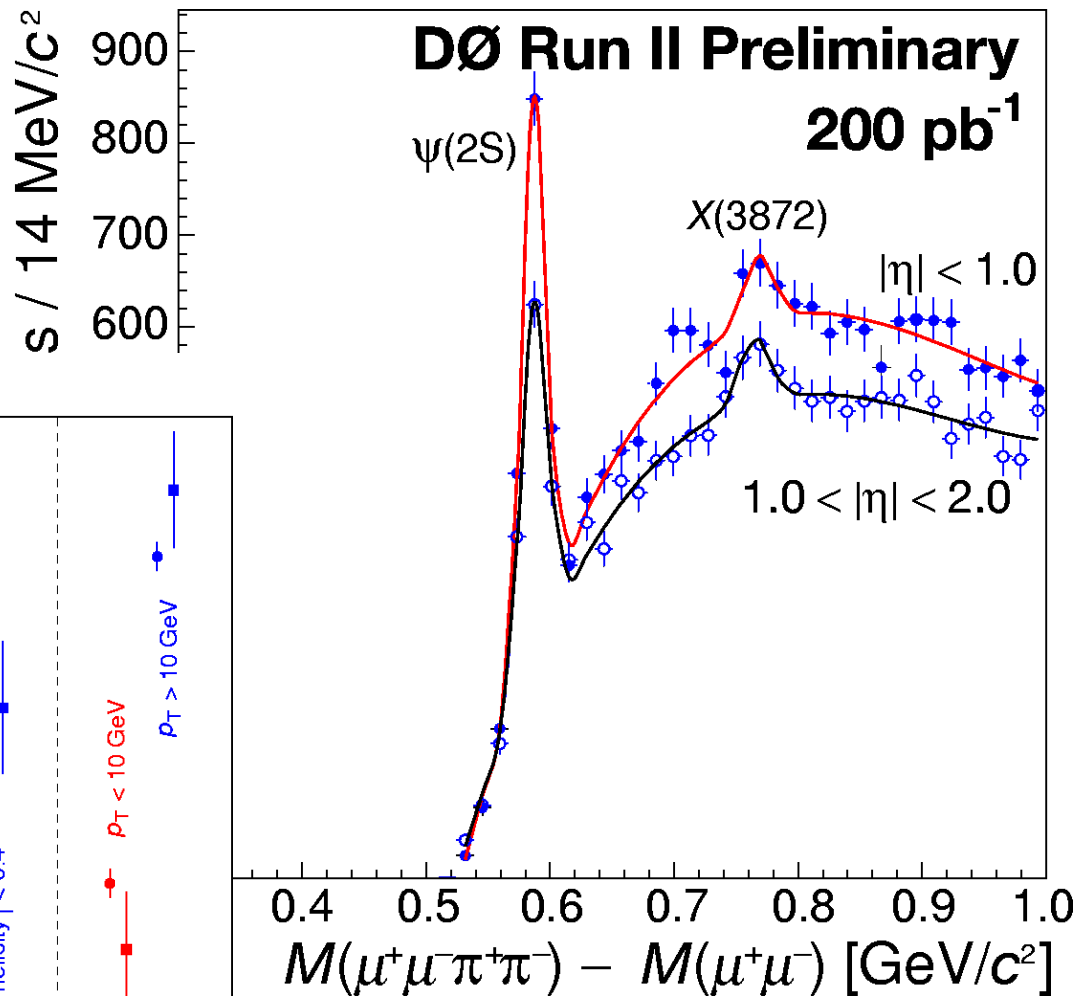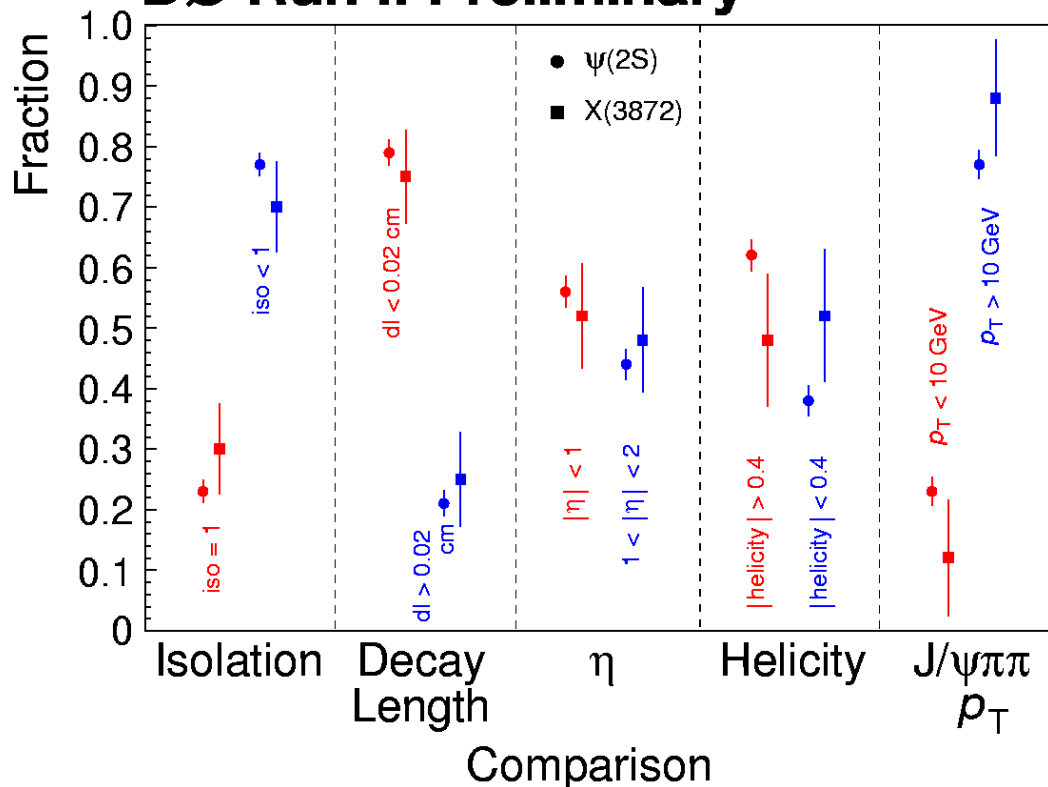
No significant differences between $\Psi(2S)$ and X have been observed

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$B_s \to \mu^+ \mu^-$ sensitivity study

$B_s \to \mu^+ \mu^-$ is a promising window on possible physics beyond the SM

Expected SM branching ratio is small:

$Br(B_s \to \mu^+ \mu^-) = (3.4 \pm 0.5) \cdot 10^{-9}$

$B_d \to \mu^+ \mu^-$ is suppressed by additional factor $|V_{td}/V_{ts}| \cong 4 \cdot 10^{-2}$

SUSY: at large tan β enhancement of up to 2-3 orders of magnitude
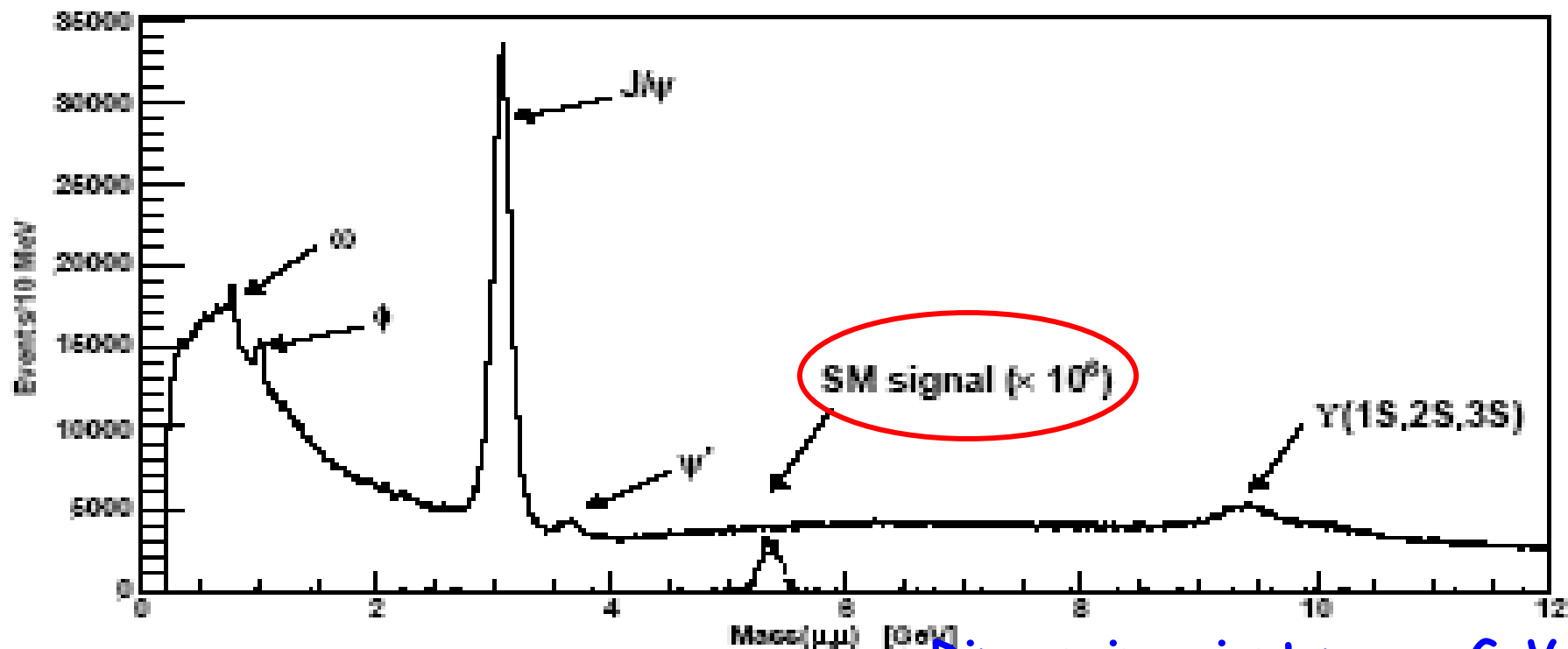
Dimuon invariant mass, GeV/c^2

$B_s \to \mu^+ \mu^-$ sensitivity study

- **Optimisation based on mass sidebands using decay length, isolation and angle between muon and decay length direction**
- **Expected signal has been normalised to $B^{\pm} \to J/\Psi\ K^{\pm}$**
- **After final cuts**
  - **expect 7.3 background events in signal region**
  - **signal efficiency: 30 %**

~180 pb^{-1}
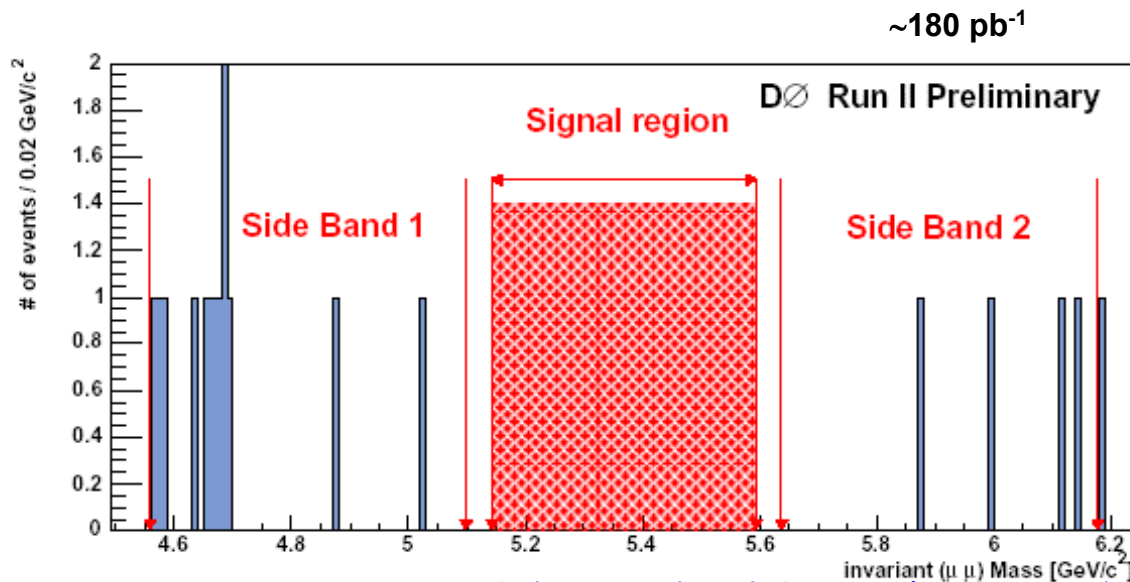
The box has NOT been opened yet

Reoptimisation still in progress - further improvements expected

Current expected limit (Feldman/Cousins):

Br($B_s \to \mu^+ \mu^-$) < 1.0 · 10^{-6} @ 95 % CL (stat + syst)

Have sensitivity for competitive measurement

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New Phenomena Searches

SUSY

Search for Squarks and Gluinos in the Jets+MET Topology
Search for mSUGRA SUSY in the Like-Sign Muon Channel
Search for Chargino/Neutralino in ee(+l) Final State
Search for Chargino/Neutralino in Trilepton Final State
Search for GMSB SUSY in Di-photon Events with Large MET

Leptoquarks

Search for the First Generation Leptoquark

Extra Dimensions

Search for LED in Jets+MET Topology
Search for Large and TeV-1 ED in Di-electron Channel
LED in Di-electron and Di-photon Channels

Z'

Search for Heavy Z' Bosons in Di-electron Channel

◆ **10 new analyses!**

Supersymmetry

particles have superpartners with spin different by 1/2

Example: Two charginos :

spin 1
spin 0

$$W^{\pm} \xrightarrow{SUSY} \widetilde{W}^{\pm} \longrightarrow$$

$$H^{\pm} \xrightarrow{SUSY} \widetilde{H}^{\pm} \longrightarrow$$

$$\mu, M_{1/2}$$
$$\tan(\beta)$$

$$\longrightarrow \widetilde{\chi}_2^{\pm} \quad \text{heavier s=1/2}$$

$$\longrightarrow \widetilde{\chi}_1^{\pm} \quad \text{lighter s=1/2}$$

"flavor"
eigenstates

mix

mass
eigenstates
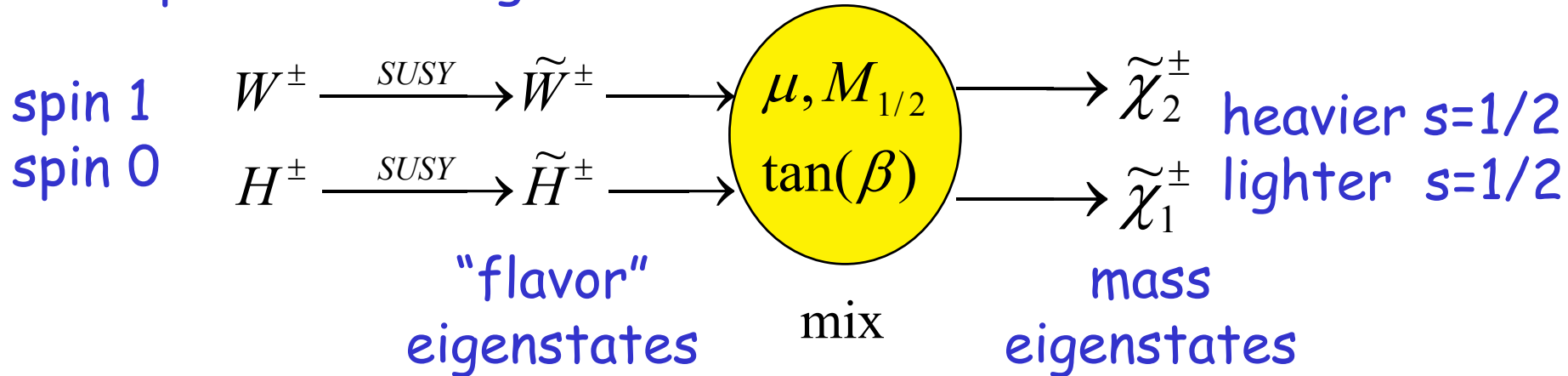
- **Field content determines couplings and decay modes**
- **Four neutralinos are fermions with s = 1/2**
- **Squarks are scalars (s = 0) but have two eigenstates each**
- **Below assume R parity conservation which means:**
  - **sparticles are produced in pairs**
  - **decay products also have sparticles**
  - **lightest sparticle (LSP) is stable**

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Masses and mixing angles can be determined solving RGE with SM constraints

Typical mass spectrum in mSUGRA
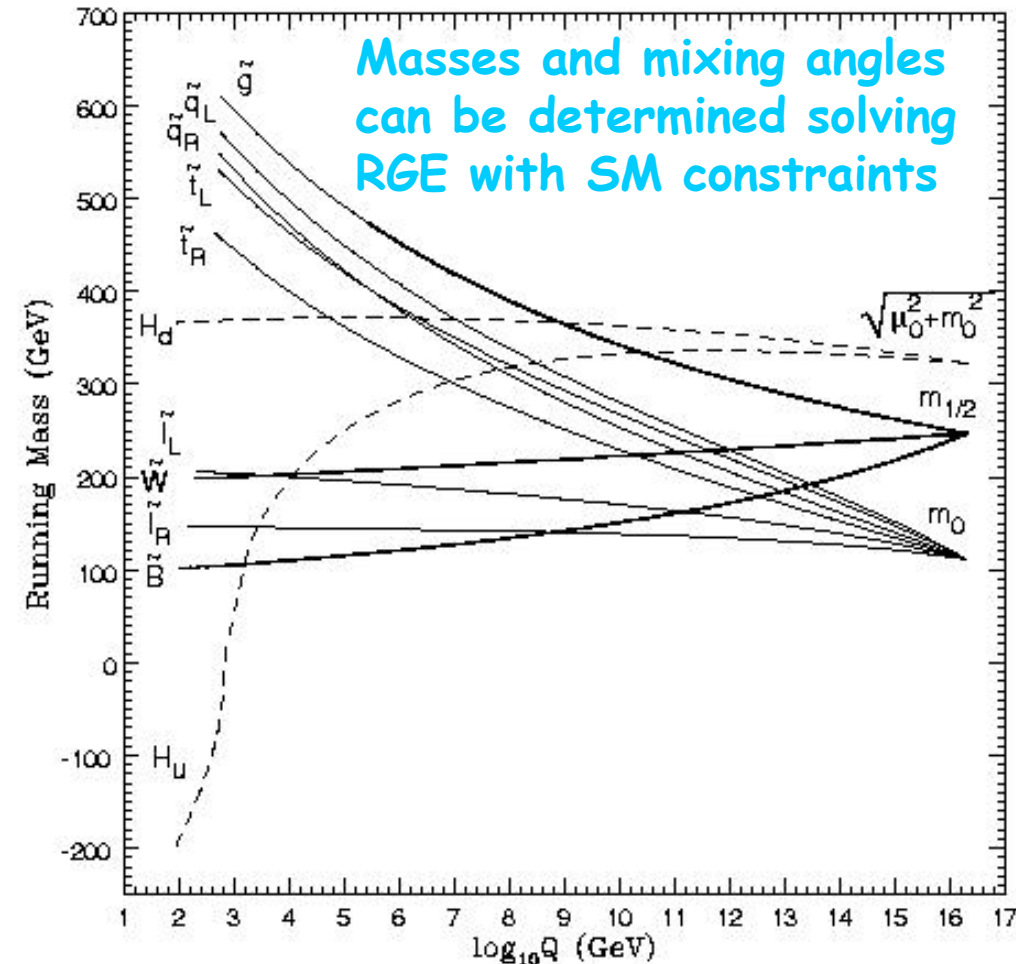
• **Many results below are interpreted in mSUGRA framework**
• **Simplest SUSY model – good benchmark**

  • **Requires only 5 parameters**

$$M_0, M_{1/2}, \tan(\beta), sign(\mu), A_0$$

  • **(Very) restricted by LEP**

• **Squarks and gluinos generally not expected to be lighter than others**

• **However, large parameter space can accommodate various mass spectra**

Andrei Nomerotski (Fermilab)

Squarks and Gluinos

- **Squarks & gluinos will be copiously produced at Tevatron**
- **Production x-sections does not depend on SUSY parameters**
  - **however have large QCD background**
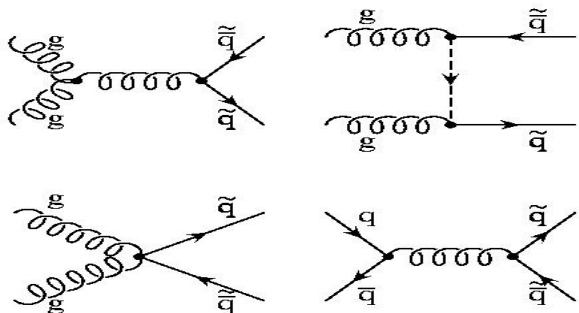
Squarks decay to   q LSP

Gluinos decay to   q $\bar{q}$ LSP

Jets + Missing Et signature

DØ Run II Preliminary
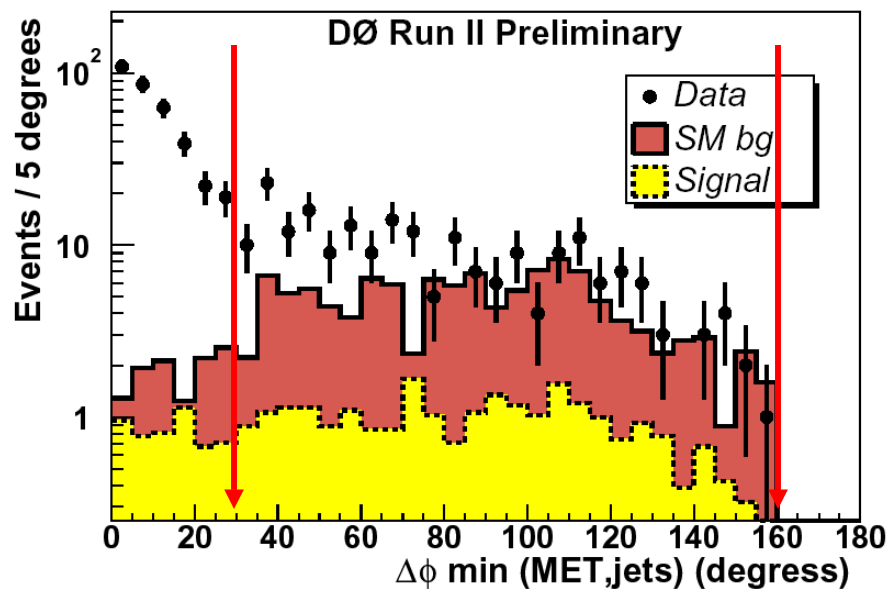
- Data
- SM bg
- Signal

Dataset : 85 pb^{-1} (Apr-Sept 2003)
Selections
- **Two jets : E_T>60 & 50 GeV**
  - **Jet EM fraction < 0.95**
- **Missing E_T > 60 GeV**
- **Topological cuts against mismeasured QCD background**
  - **30 º < $\Delta\phi$ (jet,MET) < 165 º**

27 At this stage sample is dominated by QCD

Andrei Nomerotski (Fermilab)

Squarks and gluinos

- **Final cuts :**
  - ◆ **Missing E_T >175 GeV**
  - ◆ **H_T >275 GeV**

- **4 events left**
  - ◆ **2.7 expected from SM sources: mostly Z/W production**

DØ Run II Preliminary

- Data
- SM bg.
- Signal

Events / 10 GeV

Missing ET (GeV)
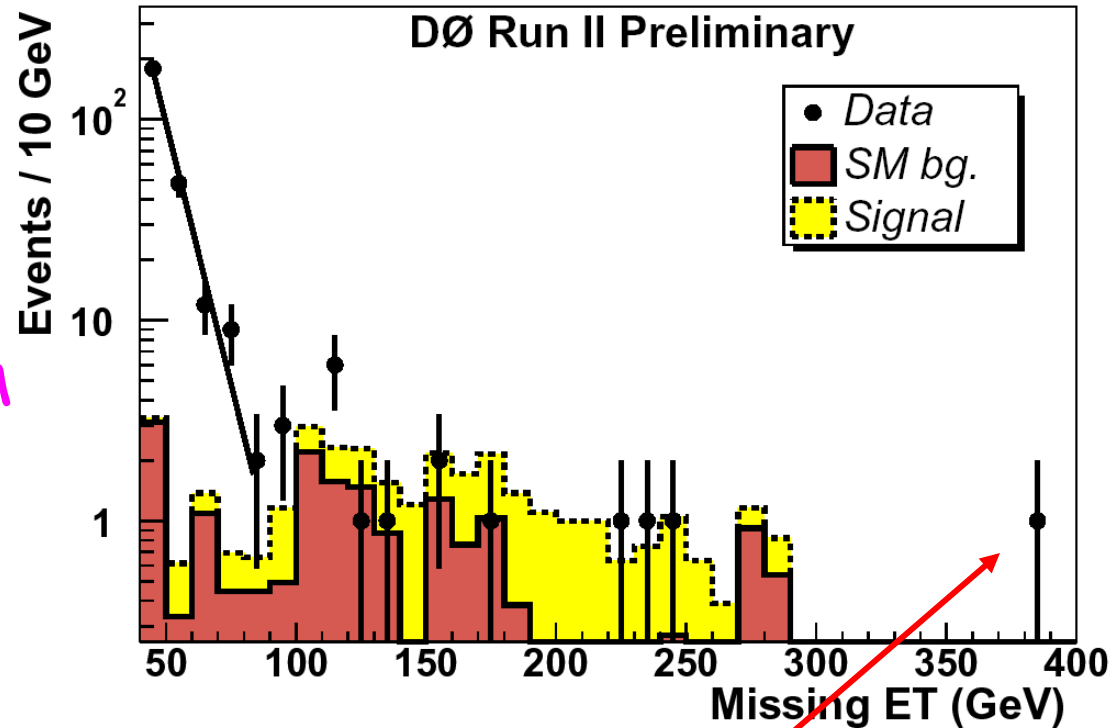
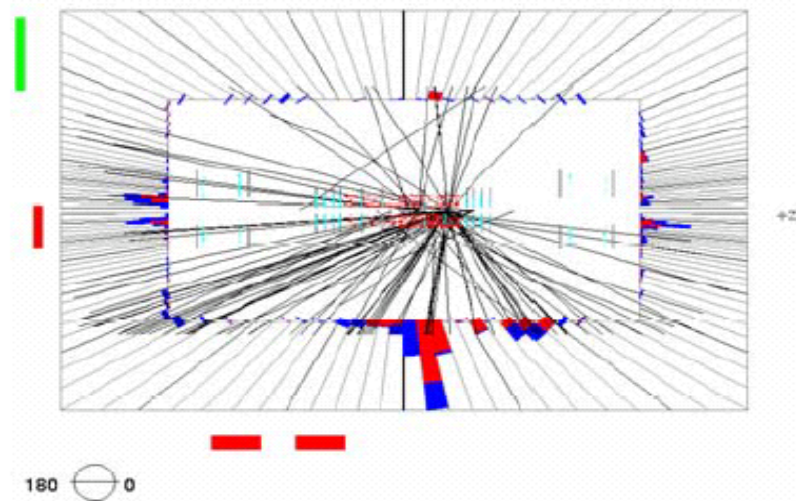**Spectacular event with huge MET = 385 GeV !**

Highest MET event

Run 180952 Event 51963432
ET scale: 88 GeV
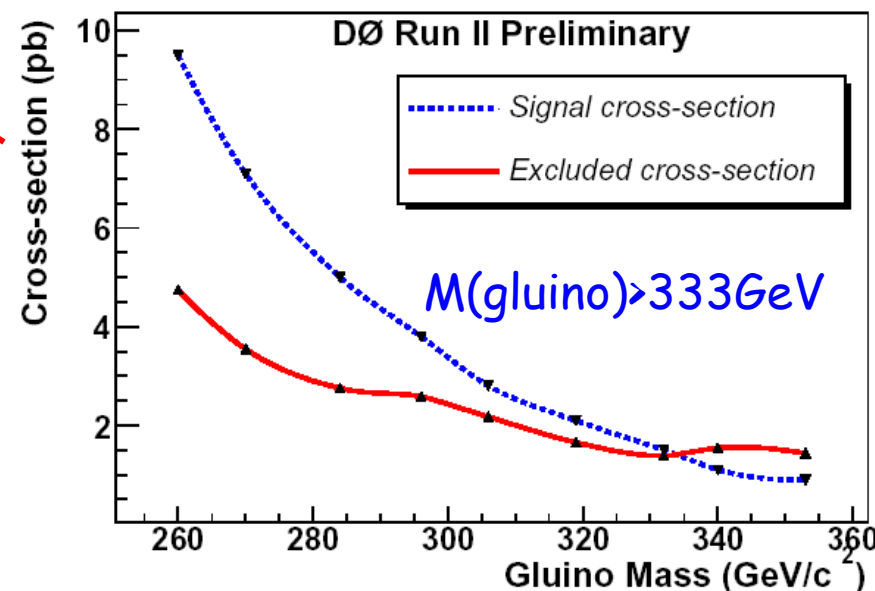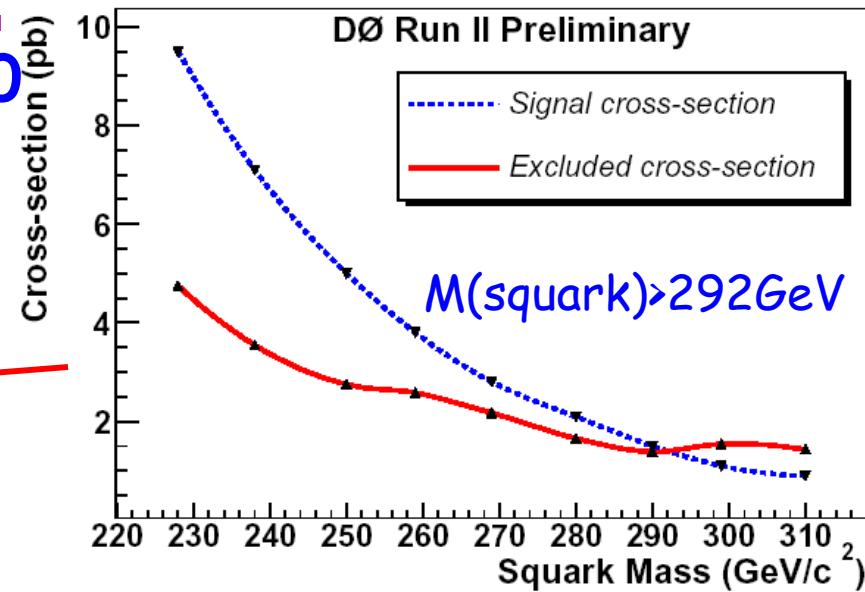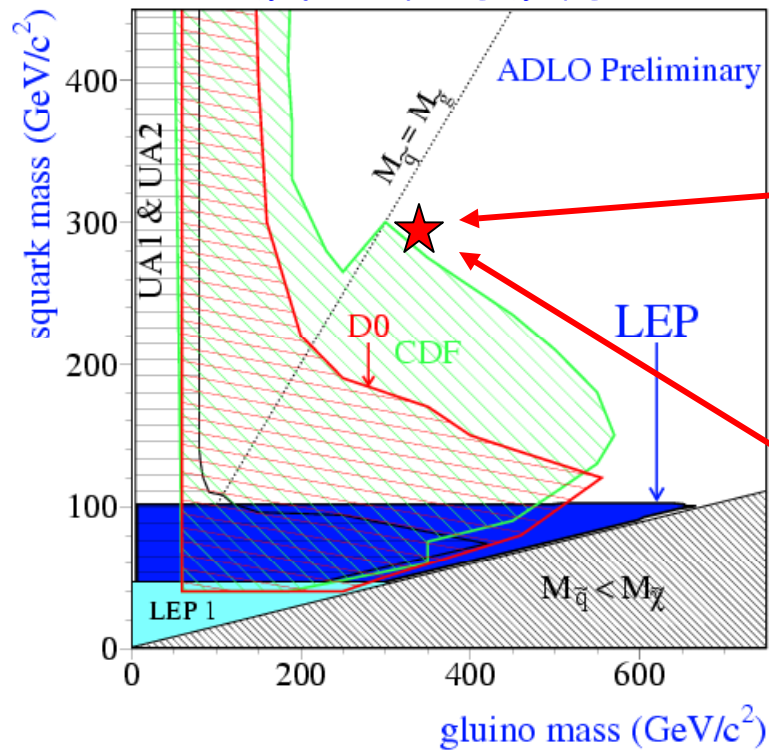
-3.7   3.7

Run 180952 Event 51963432
E scale: 95 GeV

180 — 0

Bins: 342
Mean: 1.01
Rms: 3.95
Min: 0.00949
Max: 48.9

mE_t: 247
phi_t: 134 deg

50

ET (GeV)

360

180

phi

0   -4.7   -3   -2   -1   0   1   2   3   4.7

eta

milab)
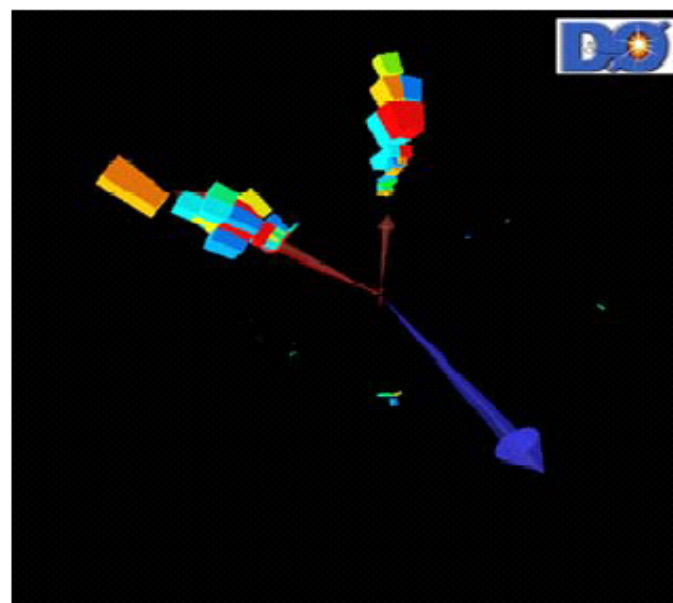
Squarks and gluinos

- M_0=25GeV; A_0=0; $\tan\beta$=3; μ<0

Run I results

- **Getting into new region !**
- **Mapping work in progress**

DØ Run II Preliminary

- Signal cross-section
- Excluded cross-section

M(squark)>292GeV

DØ Run II Preliminary

- Signal cross-section
- Excluded cross-section

M(gluino)>333GeV

Trilepton signature is one of cleanest SUSY signatures

- ◆ Chargino-Neutralino production
- ◆ Decay to WZ (or sleptons) + 2 LSP

- ◆ Low SM background
- ◆ But also : Small x-section
  - ▲ Leptonic Br are enhanced if slepton masses are close to gaugino (i.e. chargino_1 in mSUGRA) masses

2 like-sign leptons signatures available
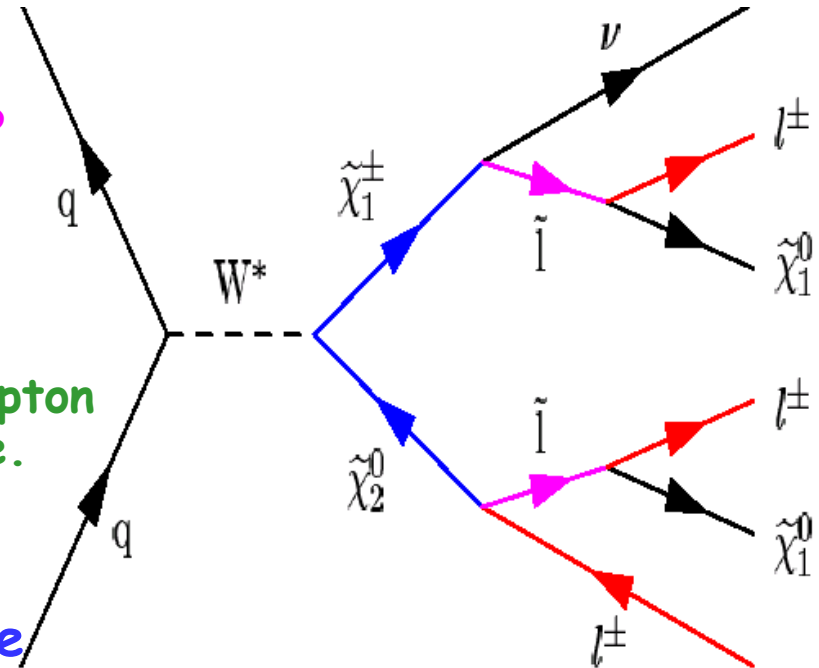
Strategy:

Combine ee(l), eμ(l), μ⁺μ⁺

ee+lepton

- **Dataset : 175 pb^{-1}**
- **Selections**
  - **2 Electrons: EM cluster+track match**
  - **P_T>12 (8) GeV/c**
  - **$|\eta|$<1.1 (3.0)**
  - **Anti-Z**
    - ▲ 15 < M_{ee} < 60 GeV/c^2
    - ▲ $\Delta\phi(ee)$ < 2.8
  - **Anti-W→(eν)+γ**
    - ▲ hits in silicon or tighter electron likelihood
  - **Anti top**
    - ▲ Veto jets with E_T > 80 GeV
  - **Anti-Drell Yan**
   - ▲ Missing E_T > 20 GeV
    - ▲ $\Delta\phi$(e MET) > 0.4

D0 Run II preliminary

data
Z -> ee
Y -> ee
W -> enu
Z -> tt
QCD
ZZ,WZ,WW
tt -> ee

Potential signal

invariant diEM mass (GeV)
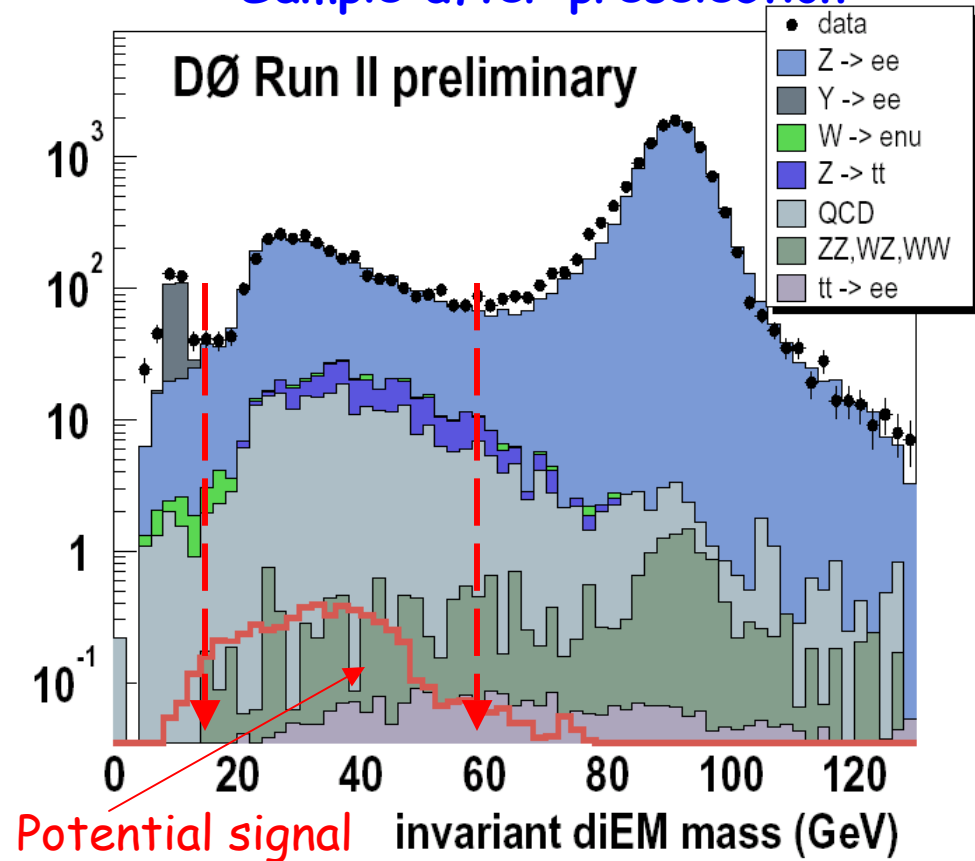
- **Extra lepton = isolated track**
  - ▲ P_T>3GeV

- **After final cuts : observe 1 event, expect 0.27**

Andrei Nomerotski (Fermilab)

eμ channel

- **Dataset : 158 pb^{-1}**
- **e: Pt >12 GeV μ: Pt > 8 GeV**
- **Main backgrounds:**
  - **Z→μμ, ττ**
  - **Wj, WW**
  - **top**
  - **QCD multijet**
- **Selections**
  - **Z/W vetos, topological cuts (e μ)**
  - **Missing E$_T$ > 15 GeV**
  - **Jet veto**
  - **15 < M(e μ) < 100 GeV**

Sample after preselection
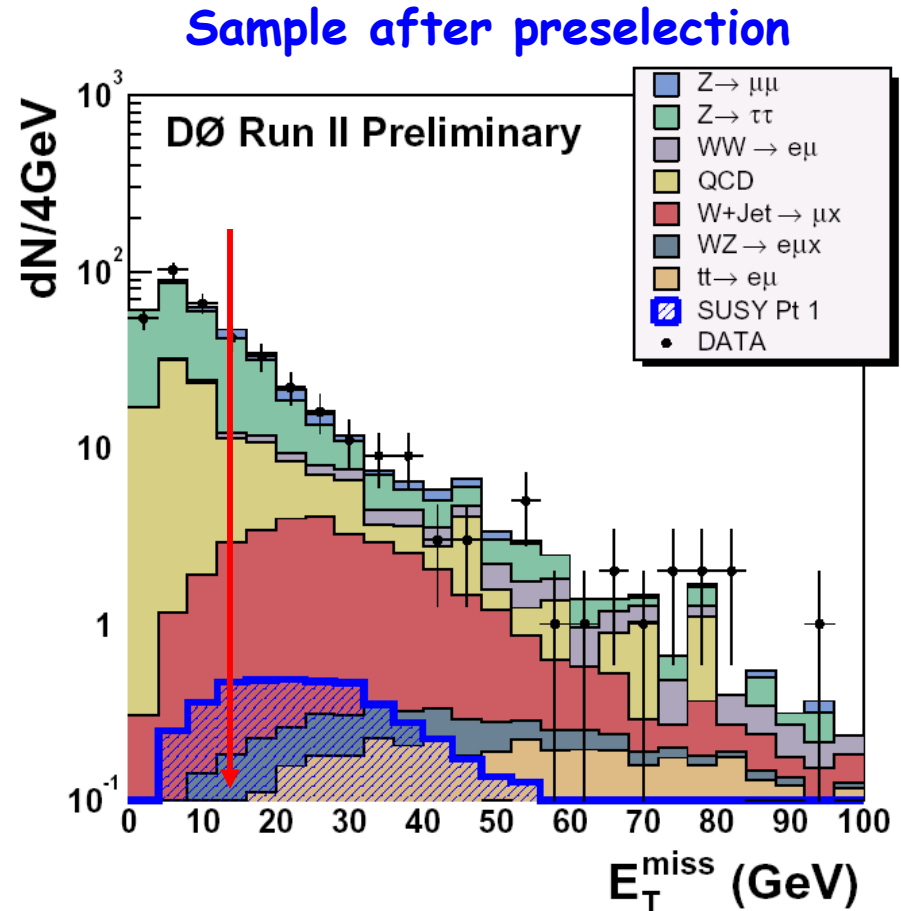
- **After final cuts 1 event left, 2.9 expected from SM sources**
- **Requiring additional lepton : 0 events left, 0.54 expected**
  - **0.9 SUSY events expected at best**

Like-sign muons

- **Dataset : 158 pb^{-1}**

- **Two muons**
  - P_T > 11 & 5 GeV
  - **calorimeter and track isolation**

- **Missing E_T >15 GeV**

- **Most backgrounds from bb/cc and sign misidentification**
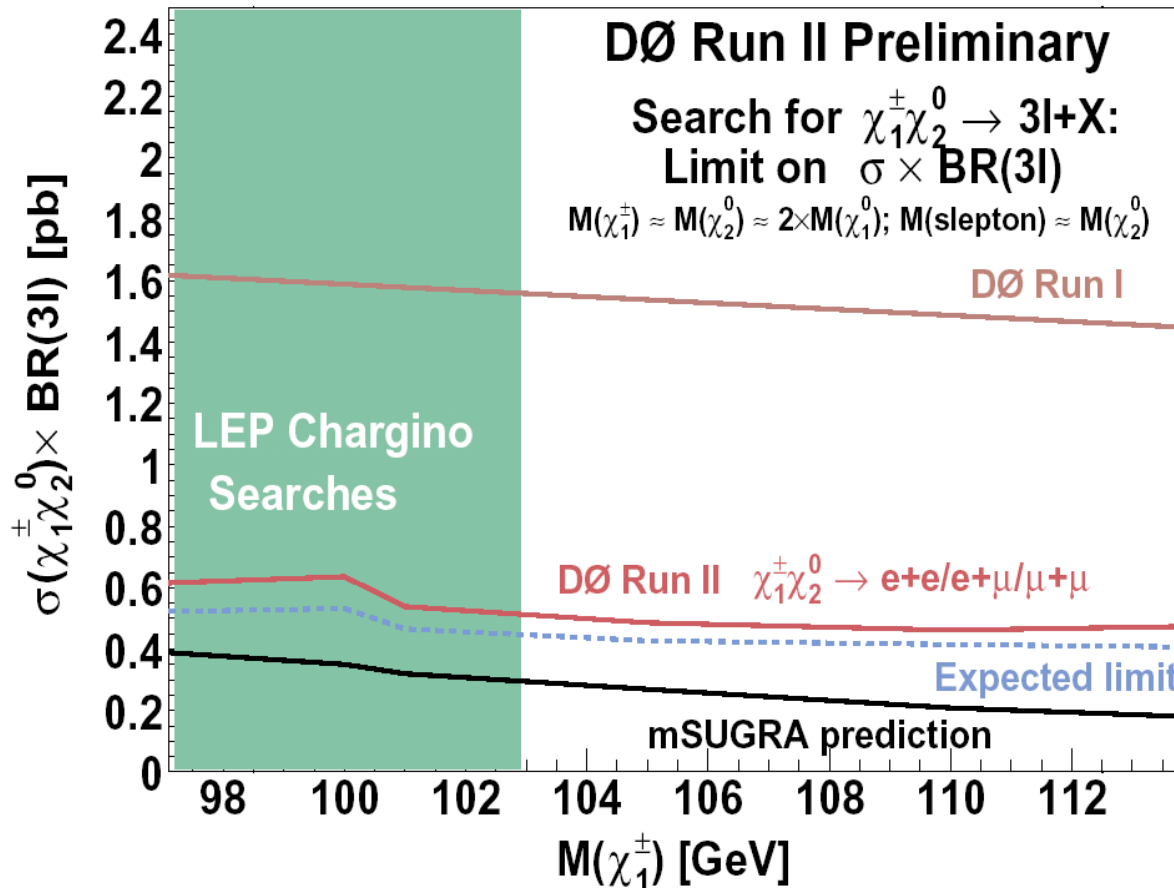 - **scaled from like-sign data for non-isolated μ's**

- **Anti WZ, ZZ cuts**

Run II Preliminary

▼ *OS Data*
● *LS Data*

Events / 3 GeV

Invariant Mass (GeV/c^2)
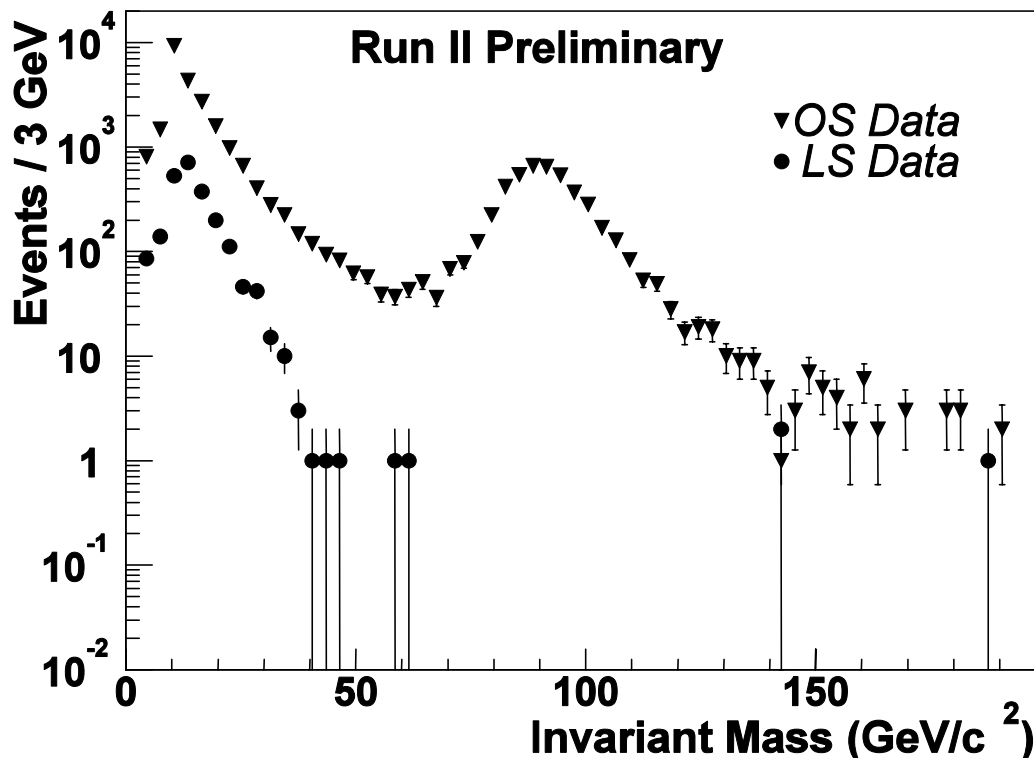
1 event survived, 0.23 expected

Combined trilepton result

- **First exercise on combination of all trilepton searches**
  - ◆ **Correlations included**

- **Run I cross section limit much improved**
- **mSUGRA prediction within reach (for the best scenario)**

Di-photons : GMSB SUSY

- **Gauge Mediated Symmetry Breaking (GMSB) at scale Λ**
  - **Light Gravitino (<<eV) is LSP, NLSP can be neutralino or slepton**
- **If neutralino NLSP:** $\tilde{\chi}_1^0 \to \gamma \tilde{G}$

  All standard SUSY signatures complemented by two photons

  $\Rightarrow$ **inclusive search for $\gamma\gamma E_T + X$**

- **EM data set 185 pb^{-1}**
- **Backgrounds:**
  - **QCD: γ+j with jet misidentified as γ**
  - **W$\gamma \to$e$\nu\gamma$ (track is lost)**
- **Selections**
  - **Two photons with P$_T(\gamma)$>20GeV in $|\eta|$<1.1**
  - **Missing E$_T$ > 40 GeV**
  - **MET separated from jets**

DØ Run II Preliminary

- - - - - Λ = 35 TeV
- · - · - Λ = 45 TeV
———— Λ = 60 TeV

● Data
—— QCD bkgr.
- - - - Total bkgr.

QCD calibration region

$E\!\!\!/_T$, GeV
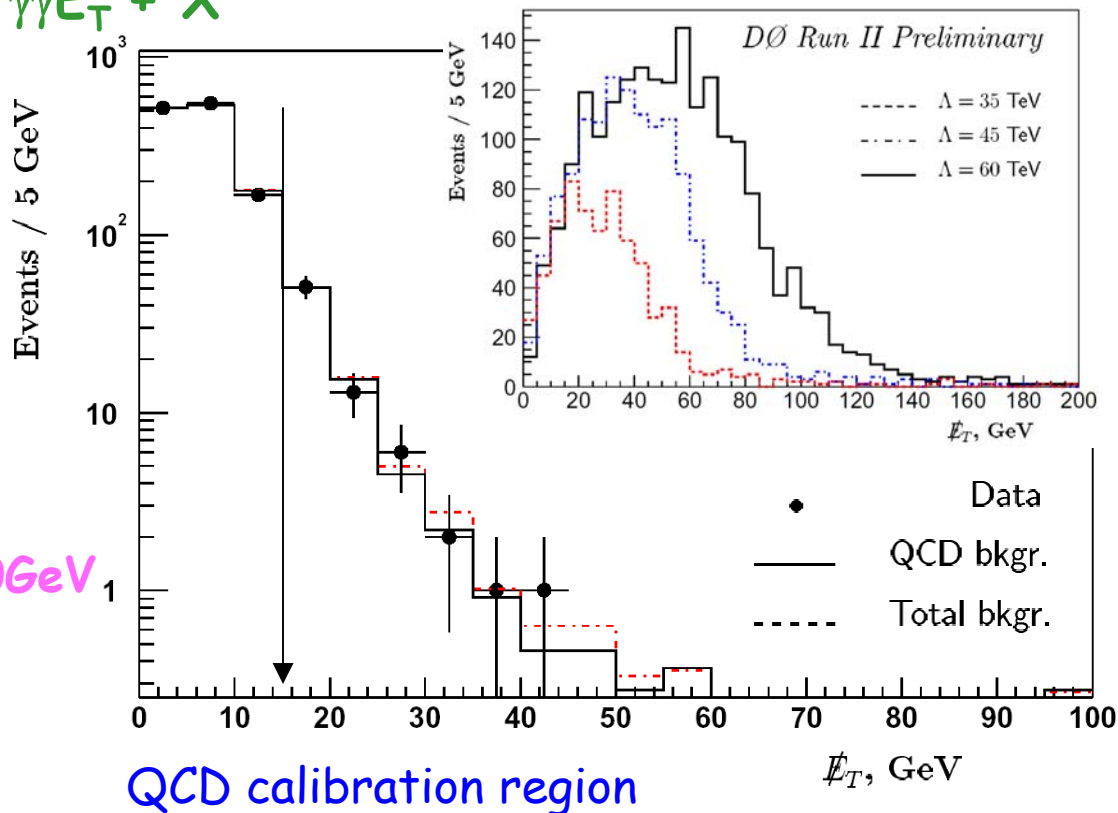
Di-photons : GMSB SUSY

- **Observed 1 event, expected 2.5 SM events**
- **Proceed to set a limit**

DØ Run II Preliminary

$N_5 = 1$
$M_m = 2\ \Lambda$
$tg\ \beta = 5$
$\mu > 0$

multiplied by k-factor

Pythia

DØ Run 1

σ [pb]

$m_{\chi_1^0}$ [GeV]

Λ [TeV]

DØ Preliminary

Excluded @ 95%CL

Excluded at 95% C.L.

$m(\tilde{\chi}_1^0)$ (GeV/c^2)

$m(\tilde{e})$ (GeV/c^2)
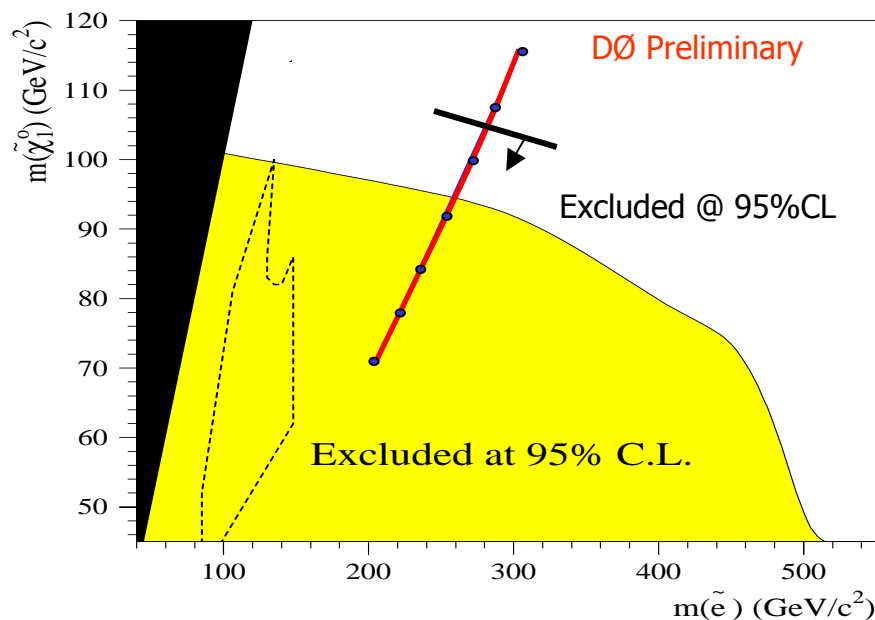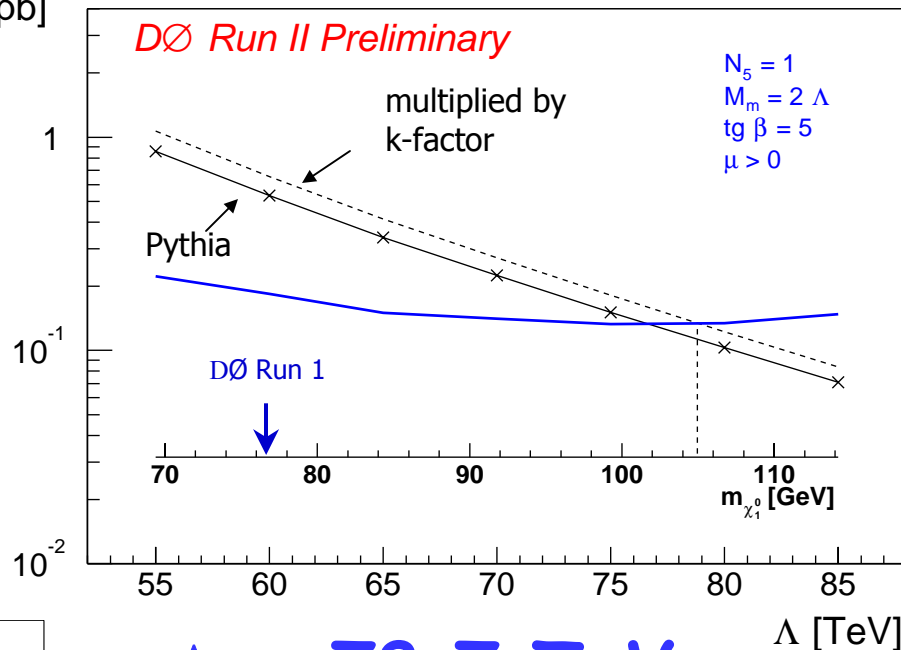
Λ > 78.7 TeV

$m(\chi_1^0)$> 105 GeV

$m(\chi_1^+)$> 180 GeV

Improves LEP limit for this model

Post-Shutdown Data: $\gamma\gamma\, e$ Event

Run 187800 Event 82968527

E scale: 63 GeV

ET scale: 64 GeV

-3.7   3.7

180   0
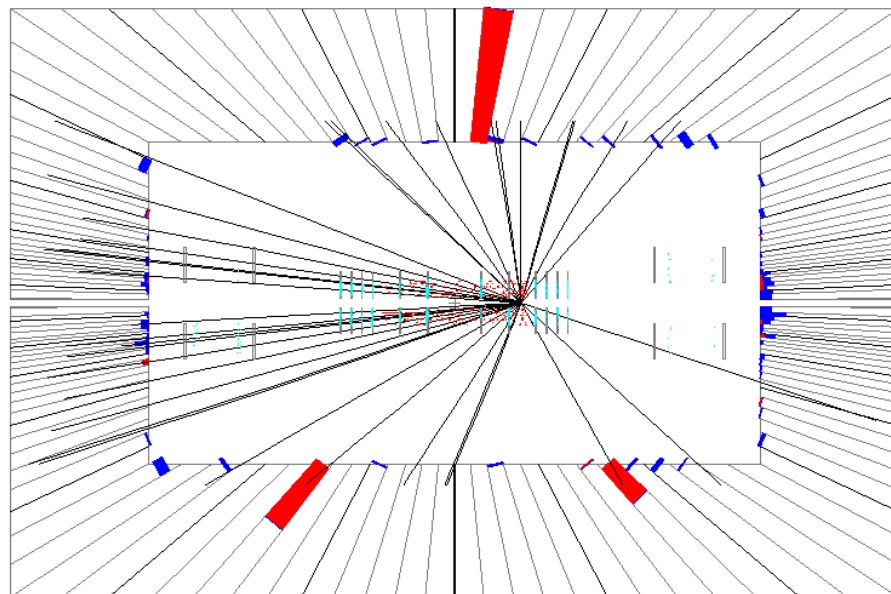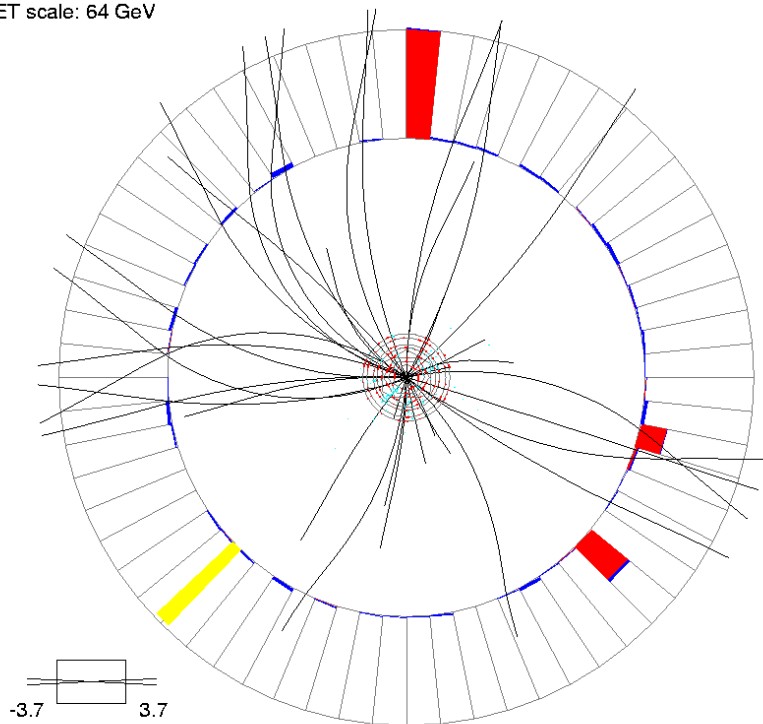
$E_T\, \gamma\, 1 = 69$ **GeV**
$E_T\, \gamma\, 2 = 27$ **GeV**
$p_T\, e\quad = 24$ **GeV/c**
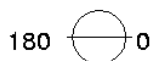
Too new : not included in the above analysis

Andrei Nomerotski (Fermilab)

Leptoquarks

- **LQ are coupled to both quarks and fermions**
  - **Predicted in many Grand Unification extensions of SM**
  - **Carry both lepton and color quantum numbers**
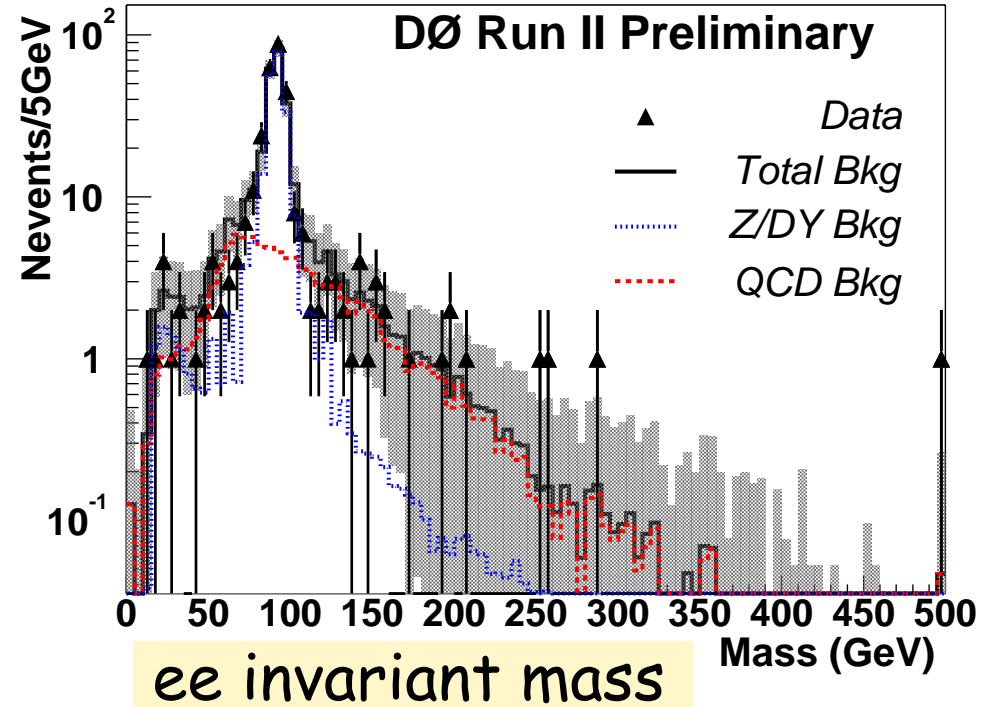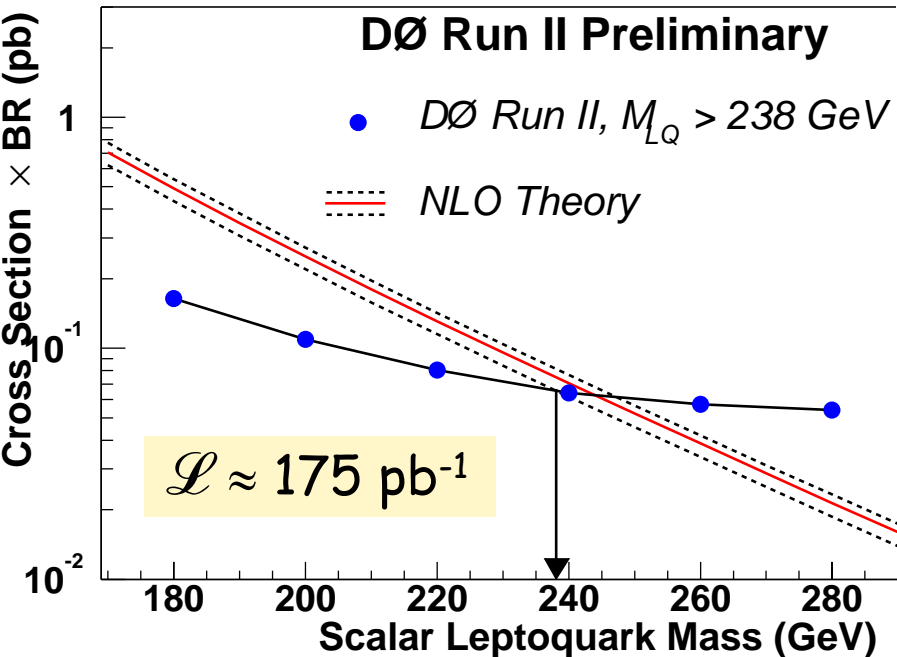- **Family diagonal coupling to avoid FCNC beyond CKM mixing**

$$(lq)(lq)$$
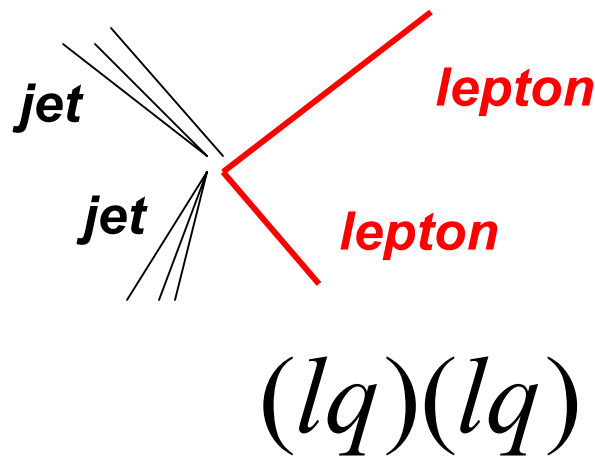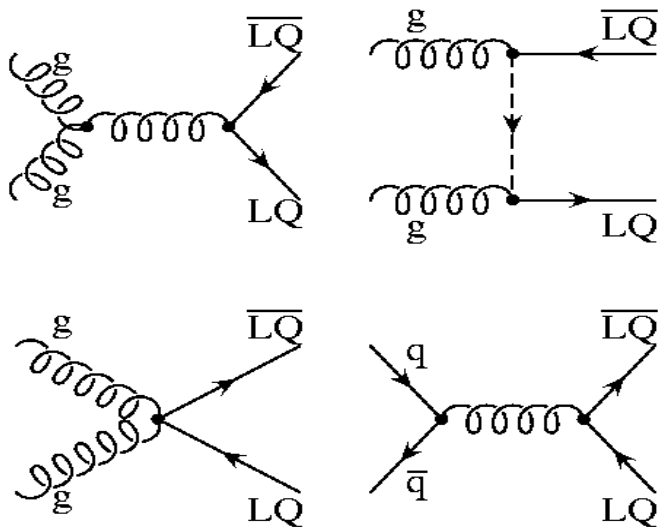
Searched first generation LQ in channels : eejj and eνjj

First generation LQ : eejj channel

- Background:

→ Drell-Yan/Z + jets,

→ QCD (with 2 fakes EM)

→ $t\bar{t}$

DØ Run II Preliminary

- Data
- Total Bkg
- Z/DY Bkg
- QCD Bkg

ee invariant mass

DØ Run II Preliminary

- DØ Run II, $M_{LQ} > 238$ GeV
- NLO Theory

$\mathcal{L} \approx 175$ pb^{-1}

Selections

→**Electrons : Et > 25 GeV**

→**Jets : Et > 20 GeV, |eta|<2.4**

→**Z veto**

→**S$_T$ > 450 GeV**

Signal Eff = 12 – 33 %

milab)

eejj candidate event

Invariant mass ~75 GeV/c², cos θ ~ -0.01

Andrei Nomerotski (Fermilab)

First generation LQ : eνjj channel

DØ Run II Preliminary

- Events/5 GeV
- data
- QCD 15<hmx7<100
- all background

M_T (eν) (GeV)
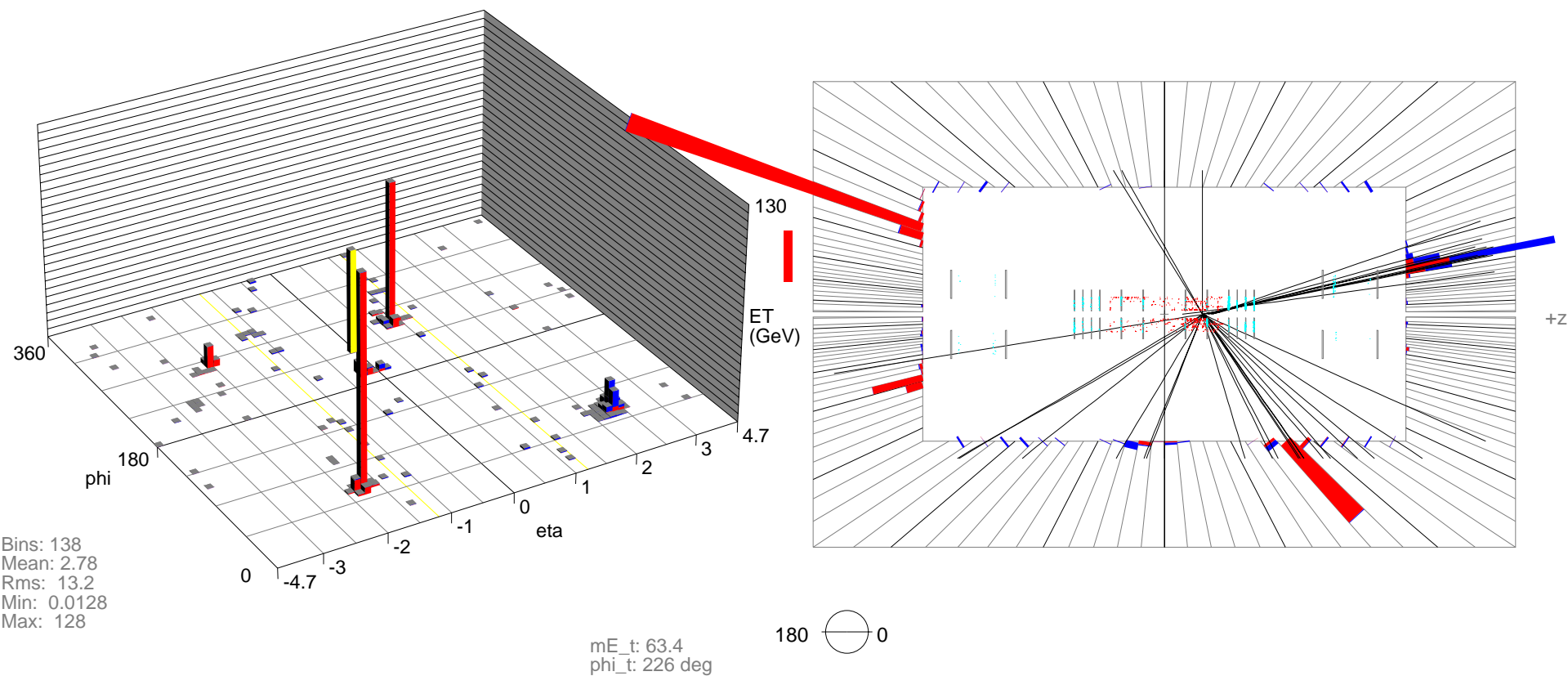
• Background:

→ W + jets,

→ QCD (with γ or fake EM)

→ $t\bar{t}$

eν transverse mass, GeV/c²

$M_{LQ1} > 192$ GeV/c²

DØ Run II Preliminary

Cross Section*BR [pb]

Scalar Leptoquark Mass [GeV]

$\mathscr{L} \approx 175$ pb⁻¹
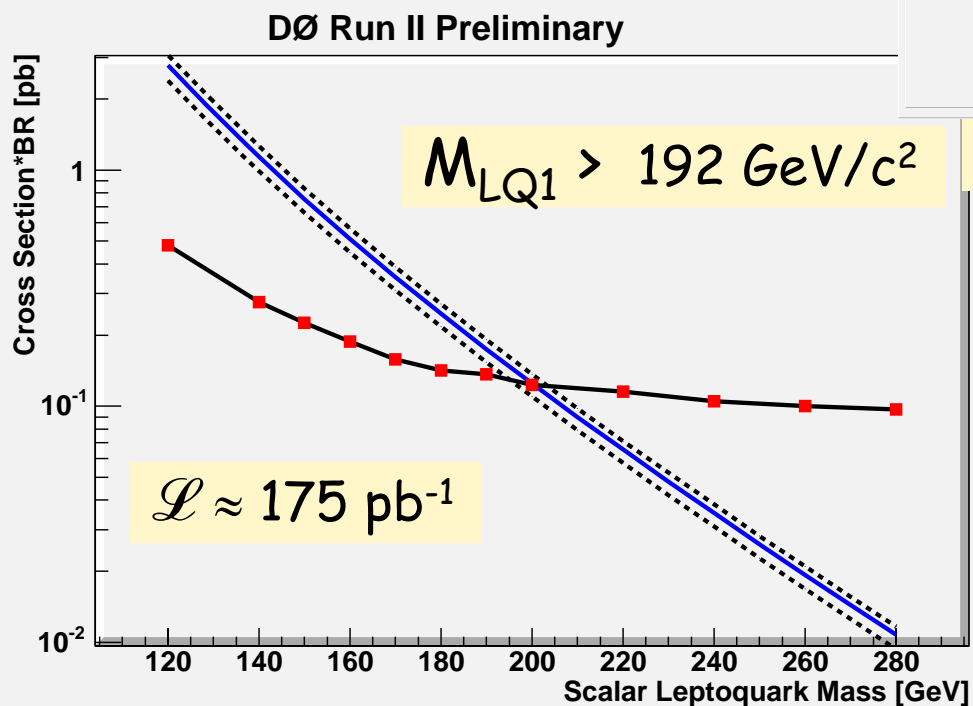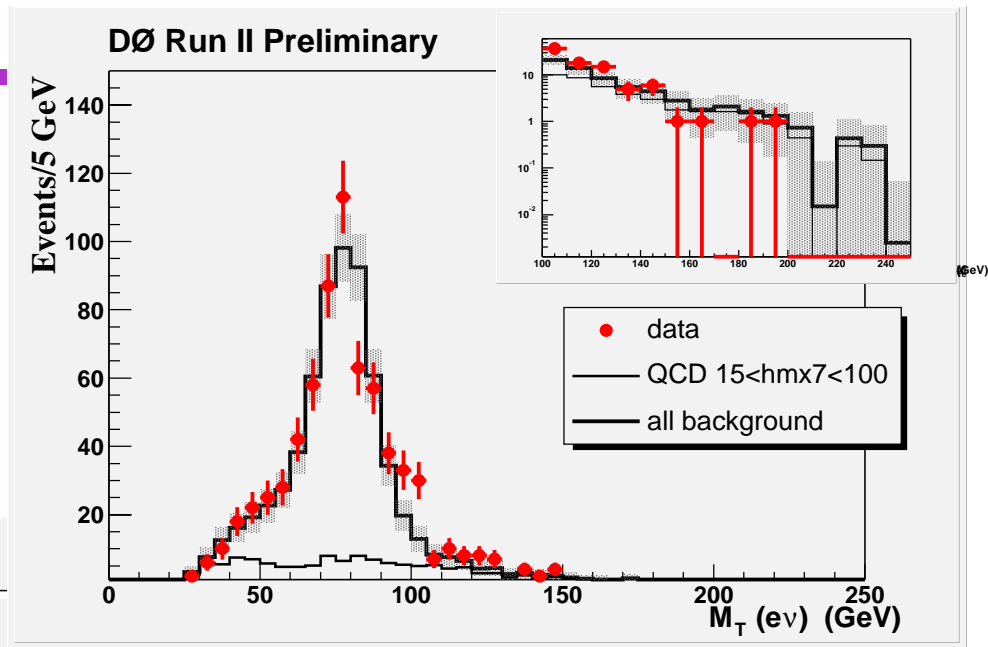
Selections

→**Electron : Et > 35 GeV**

→**Jets : Et > 25 GeV, |eta|<2.5**

→**MET > 30 GeV**

→**M_T(eν) > 130 GeV**

→**S_T > 330 GeV**

Signal Eff = 13 – 25 %

ilab)

First generation LQ : combined result

DØ Run II Preliminary

- y-axis: β = Branching Ratio (LQ → eq)
- x-axis: Scalar Leptoquark Mass (GeV)
- e ν + 2 jets
- ee + 2 jets
- DØ Run II Combined Limit
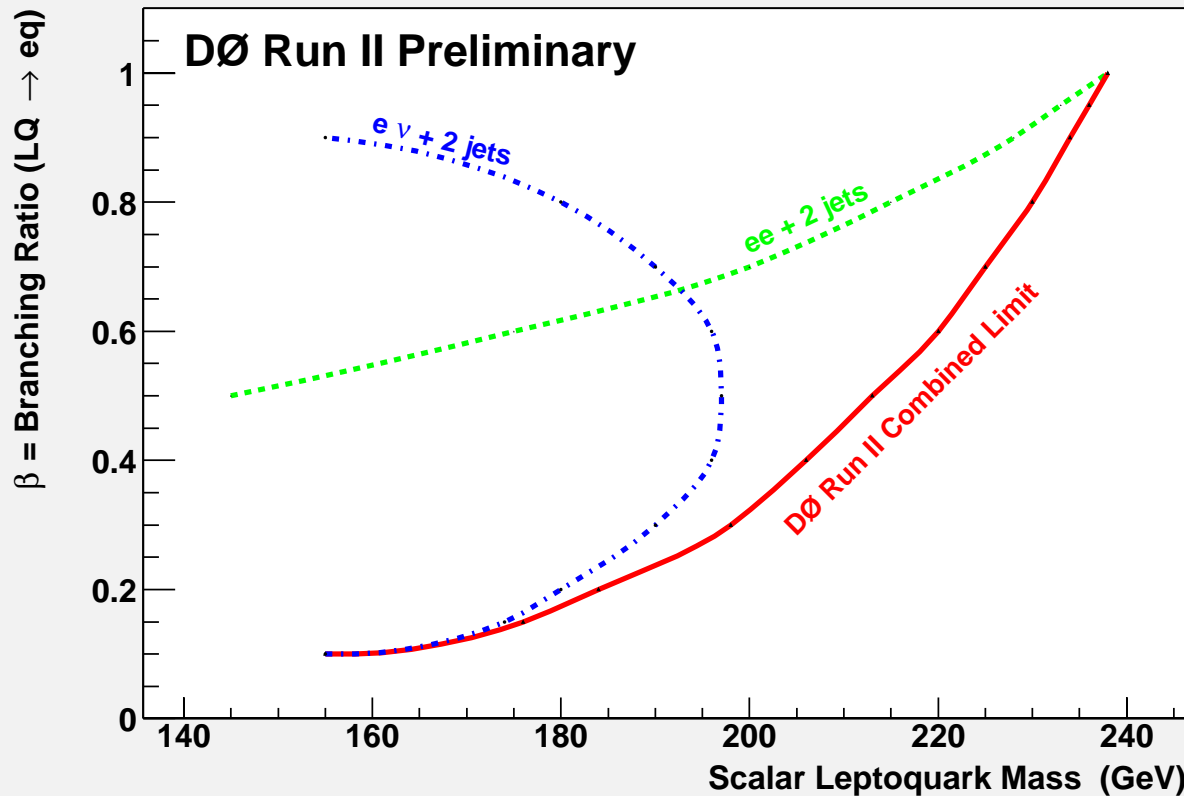
Comparable to combined CDF/DØ Run I result: 242 GeV in eejj channel

Large Extra Dimensions (LED)

- **Weakness of gravity is explained by Extra Dimensions**
    - **SM is confined to 3D-world (brane)**
    - **Gravity propagates in ED and is as strong as other interactions but this is apparent only to (3+n)-dimensional observer**

- **Can detect LED via virtual graviton effects**
    - **Searched for anomalies in e^+e^- and $\gamma\gamma$ events**

(a)   (b)   (c)
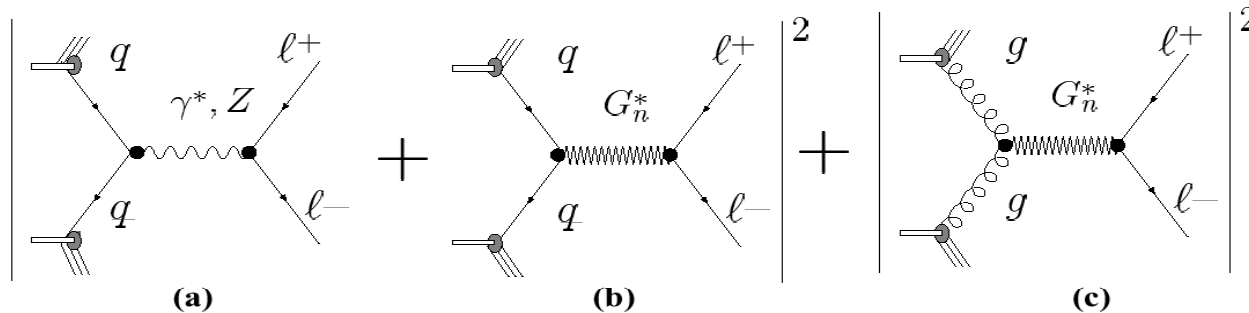
   - **Also searched for monojet signatures**
       - **Jet recoiling against G_n**

Search for ED in ee/γγ channel

- **Strategy**
  - **Use di-EM objects**
    - **Includes both ee and γγ**
  - **Fit**
    - **di-EM invariant mass**
    - **Cos θ* (scattering angle in rest frame)**
- **Dataset 200 pb-1**
- **Selections**
  - **Two EM with Et > 25 GeV with tight quality cuts**
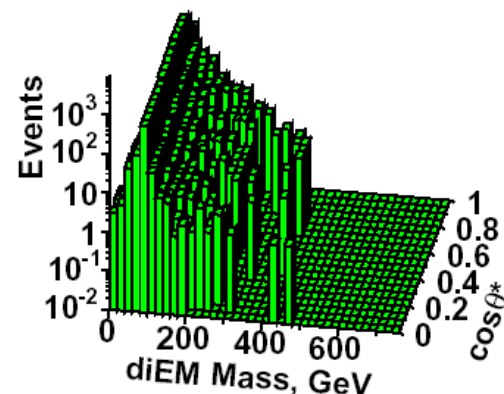 - **Fiducials**
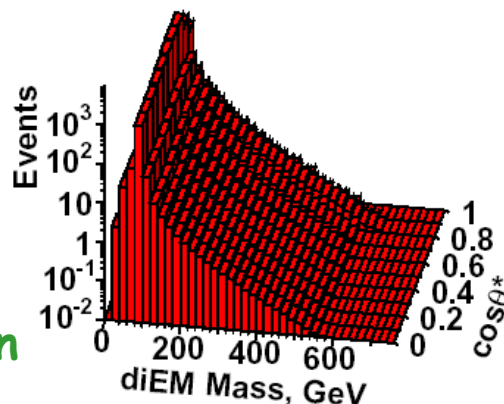   - **|eta| < 1.1 for CC**
    - **1.5 < |eta| < 2.4 for EC**
    - **Consider CC-CC and CC-EC combinations**
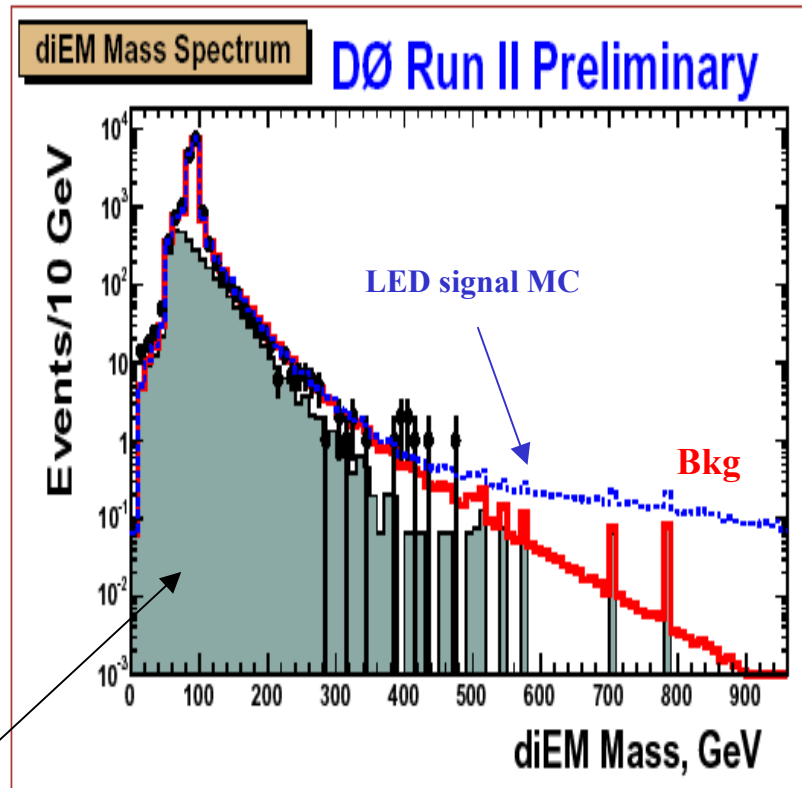

45
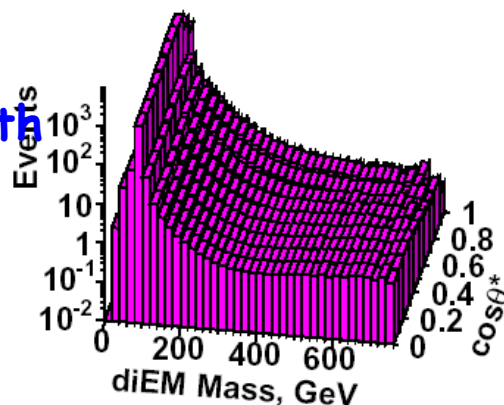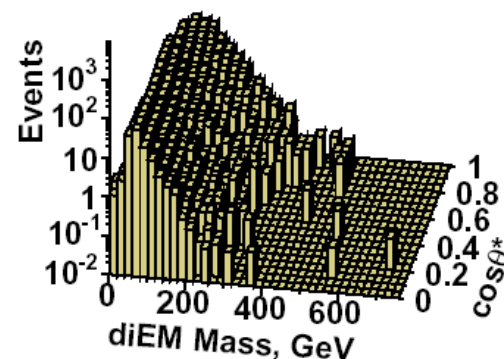
LED signal limits

- $\eta_G = F/M_S^4$
    - **Single parameter for ED effects**
- **Set limits using GRW formalism:**
    - **F=1**
- **Use CC-CC & CC-EC combinations independently, combine final results**

Results :

Run II :   Ms > 1.36 TeV

Run I + II : Ms > 1.43 TeV

most restrictive limit to date

diEM Mass Spectrum — DØ Run II Preliminary

LED signal MC

Bkg

fakes

Highest mass Drell-Yan event ever observed

Invariant mass 475 GeV/c², cos θ* = 0.01
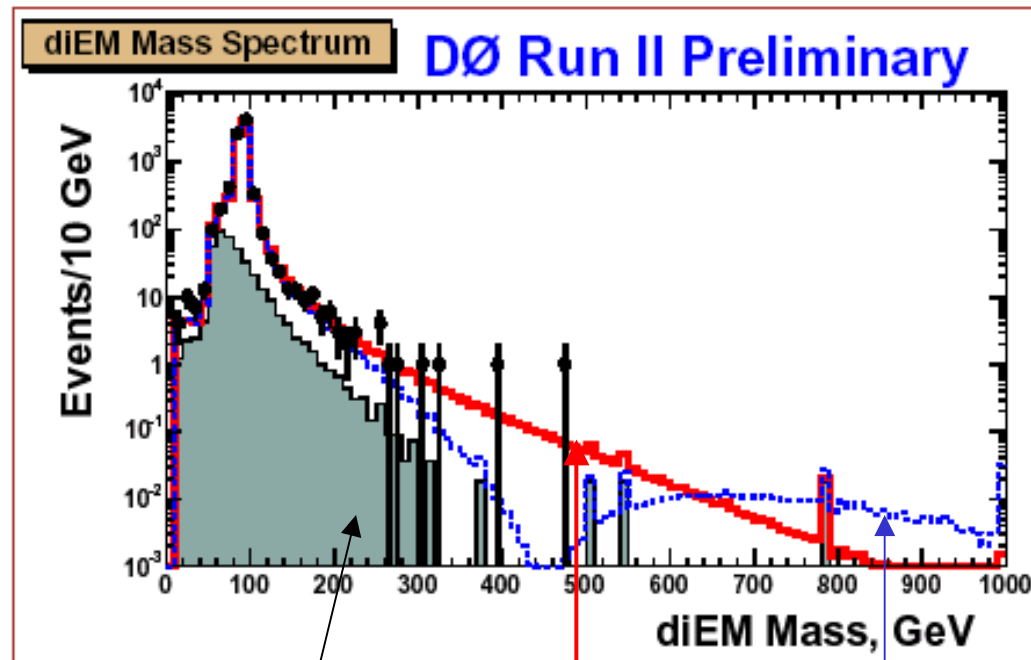
Andrei Nomerotski (Fermilab)
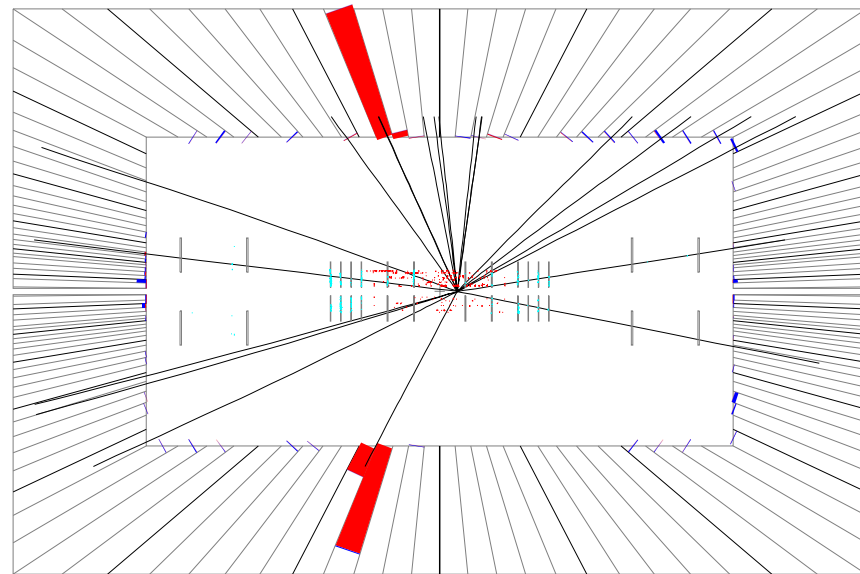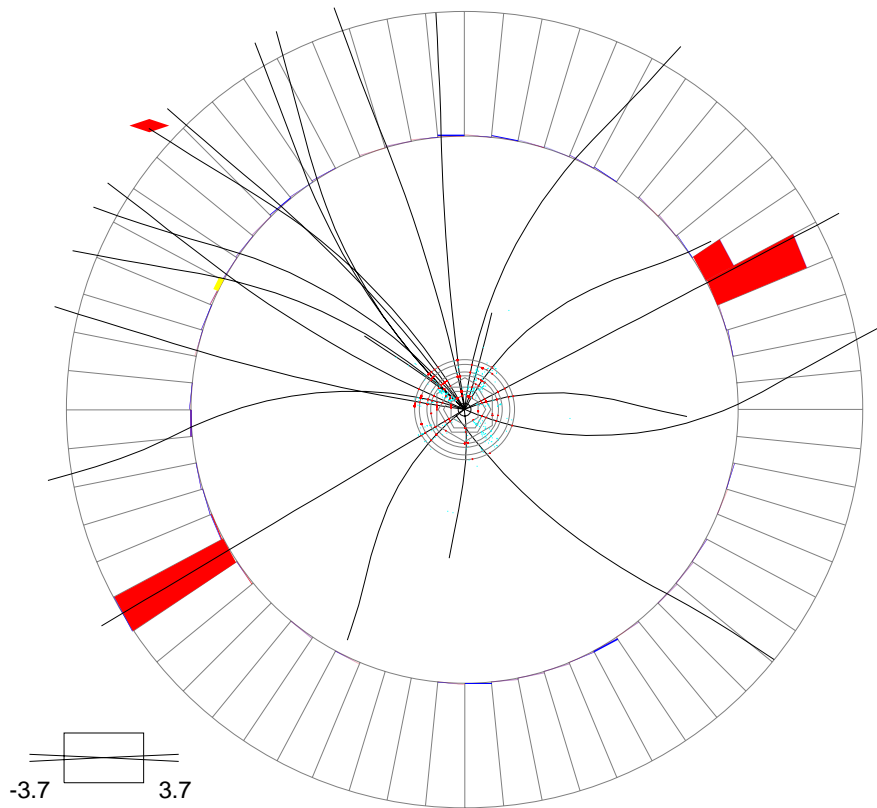
Dedicated ee Search for TeV^{-1} Dimensions

- **Another ED model:**
  - **Fermions confined to 3D world**
  - **SM gauge bosons propagate in single TeV^{-1} ED**
  - **Predicts Kaluza-Klein states of gauge bosons (W,Z,g)**
  - **R = 1/M$_c$ is size of compact dimension for gause bosons**
- **Predicts strong negative interference effects**
  - **unlike LED discussed before**
- **Use di-electron dataset**
- **Find: M$_c$ > 1.12 TeV (95% CL)**
  - **First dedicated search**

diEM Mass Spectrum · DØ Run II Preliminary

Jet mis-ID

signal

SM + fakes

Z′ Limits from ee: SM, E_6

diEM Mass Spectrum

DØ Run II Preliminary

χ^2 / ndf	62.63 / 53
Prob	0.1716
p0	24.03 ± 0.71
p1	0.01187 ± 0.00005
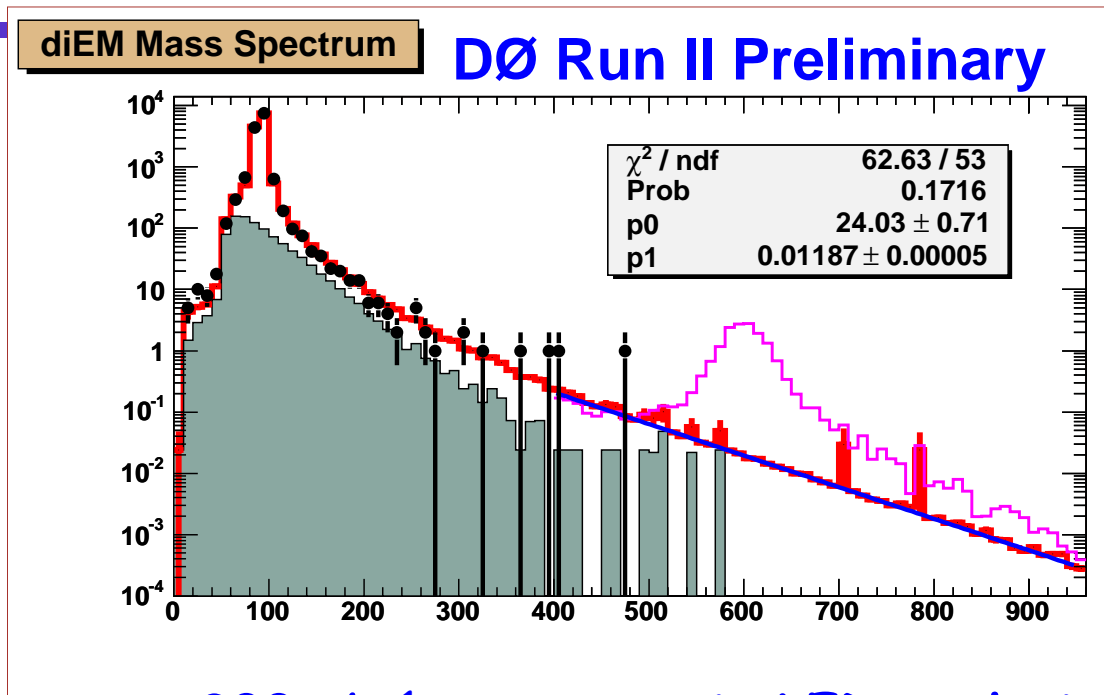
- **Dataset 200 pb^{-1} – same as in LED analysis**
- **Limits on Z′ mass in GeV/c^2:**

SM couplings	Run I	Run II	
	670	780	
E_6 couplings	Z_I	Z_χ	Z_ψ	Z_η
	575	640	650	680

Last result for today before summary

- **Dataset 85 pb^{-1}**
- **Monojet-like signature**
  - **J_1 > 150 GeV, J_2 < 50 GeV**
  - **MET > 150 GeV**
  - **$\Delta\Phi_{J,MET}$ > 30°**
- **Background: Z($\rightarrow\nu\nu$)+jet(s)**
  - **Large energy scale uncertainty**
- **Observe 63; expect 100 : set a limit on LED mass scale**
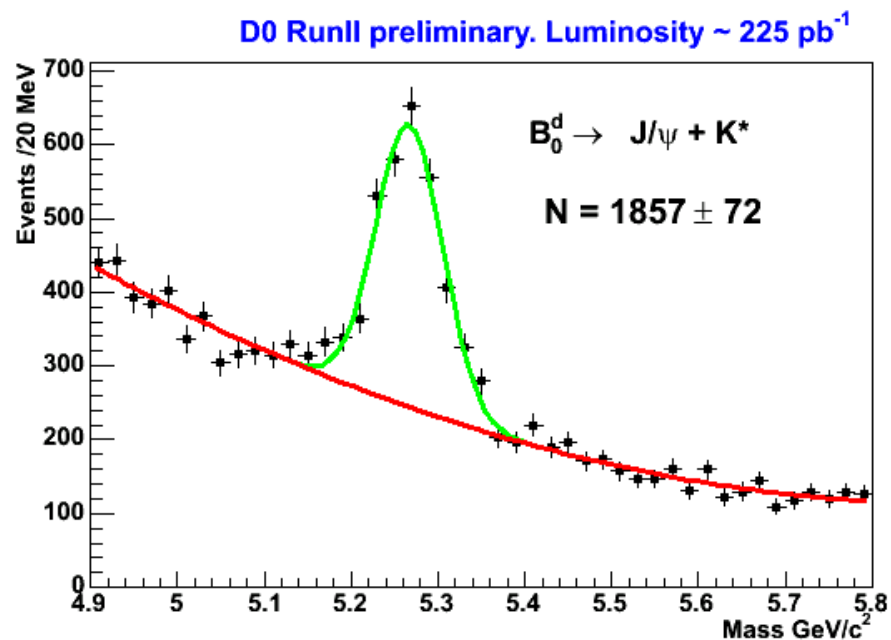

Number of dimensions

50
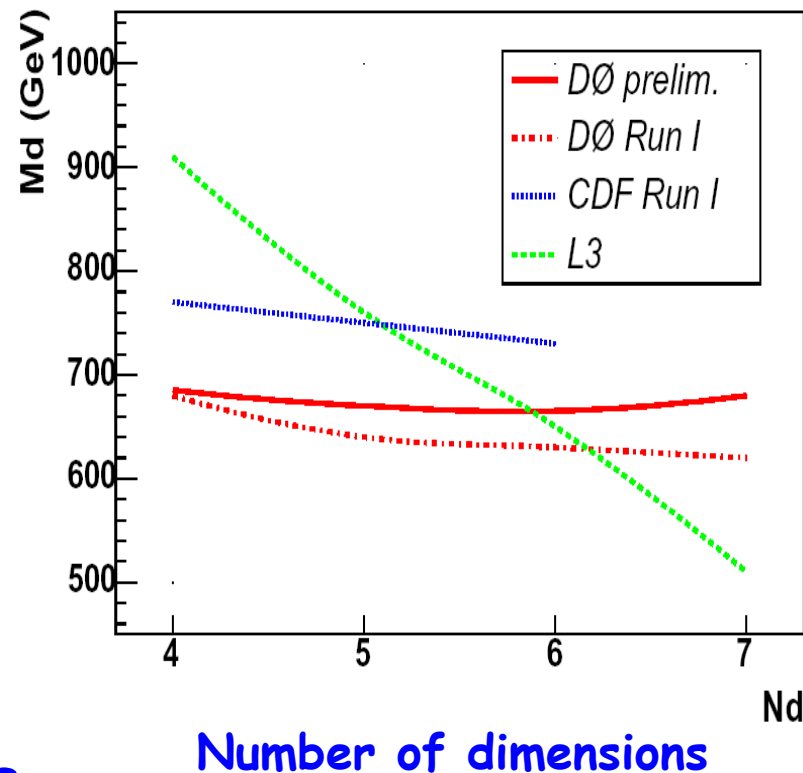
Summary

- **Presented new DØ results bound for Moriond**
  - ◆ Analyzed datasets two times larger than ever before
- **B-physics at DØ is online with world class results**
  - ◆ Record semileptonic & exclusive B samples
  - ◆ Precise measurement of B^+/B^0 lifetime ratio
- **New Phenomena searches are already probing grounds beyond Run I in**
  - ◆ Supersymmetry
  - ◆ Large Extra Dimensions and Z' sectors

- **QCD / EW / Top / Higgs part to follow in two weeks in Wine & Cheese talk by Gordon Watts**

51

Back-up slides

Exclusive B decays

D∅ Run II Preliminary, Luminosity =225pb⁻¹

$\Lambda_b \to J/\psi + \Lambda$

N = 52 ± 13

GeV/c²

D0 RunII preliminary. Luminosity ~ 225 pb⁻¹

$B_0^d \to J/\psi + K^*$

N = 1857 ± 72

Events /20 MeV

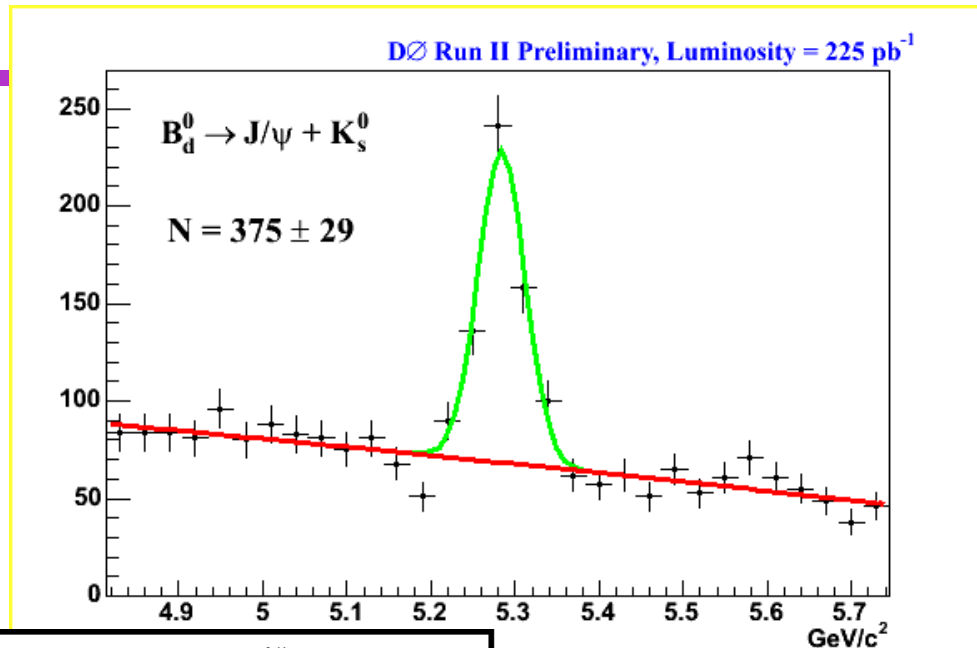Mass GeV/c²

Andrei Nomerotski (Fermilab)
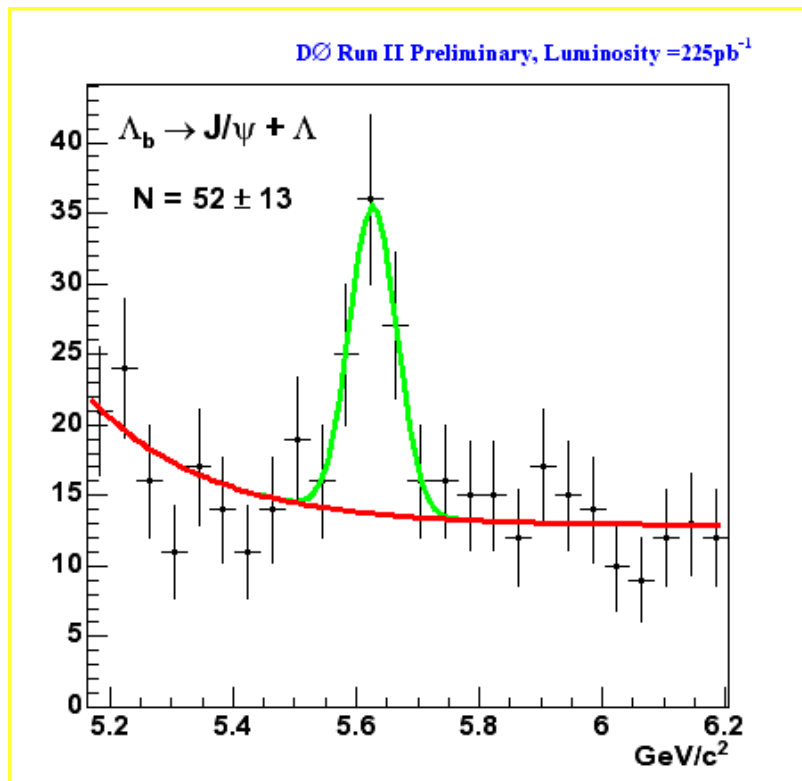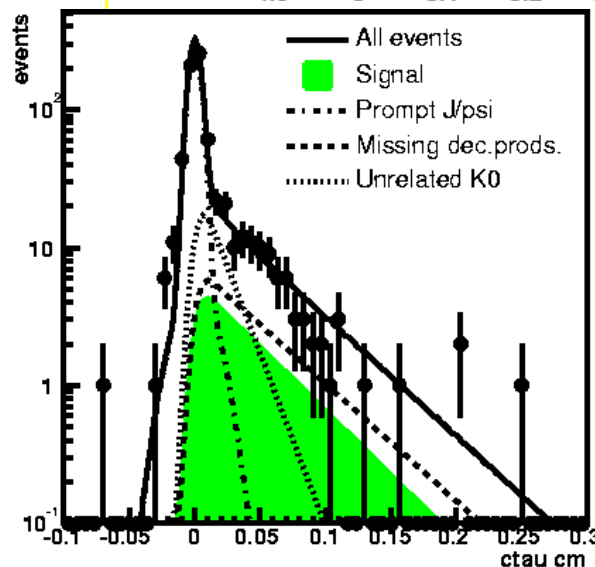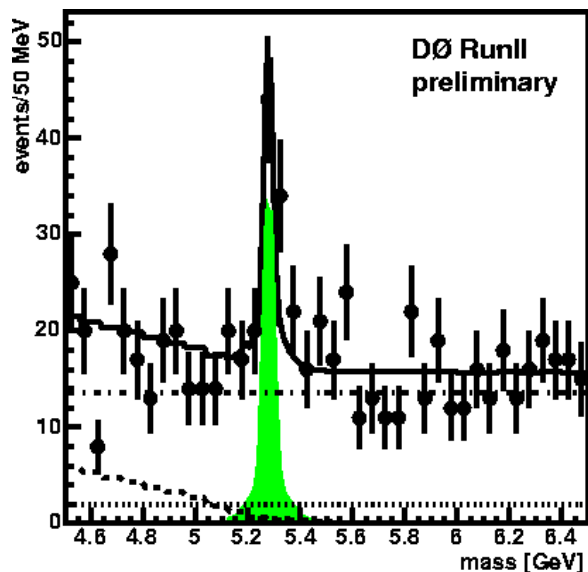
Lifetime in Exclusive B decays

Preliminary lifetime measurement using $B^0 \to J/\Psi(\mu^+\mu^-) \, K_S(\pi^+\pi^-)$:

$\tau(B^0)$
  = 1.56 $^{+0.32}_{-0.25}$ (stat) $\pm$ 0.13 (syst) ps

Consistent with world average:
$\tau(B^0)$ = 1.542 $\pm$ 0.016 ps [PDG]

D∅ Run II Preliminary, Luminosity = 225 pb⁻¹

$B^0_d \to J/\psi + K^0_s$

$N = 375 \pm 29$

Used ~110 pb⁻¹ dataset

$\tau(B^+)/\tau(B^0)$: fitting strategy

- Group events into 8 bins of
Visible Proper Decay Length (VPDL):

$$VPDL = L_T / p_T(\mu\, D^0) \cdot M_B$$

L_T = transverse decay length

- Measure $r_i = N(\mu^+ D^{*-})/N(\mu^+ D^0)$ in each bin i.
Combinatorial background with true D^0 in D^* sample is
subtracted using wrong-sign distribution
(normalisation from full sample, previous slide).

$\Rightarrow$ no need for parameterisation of
background VPDL distribution
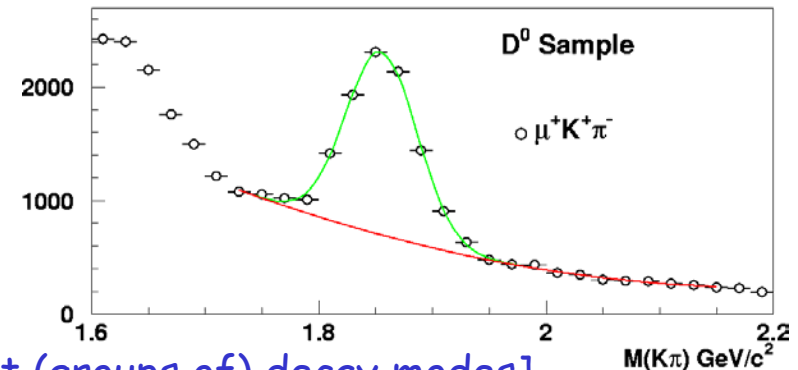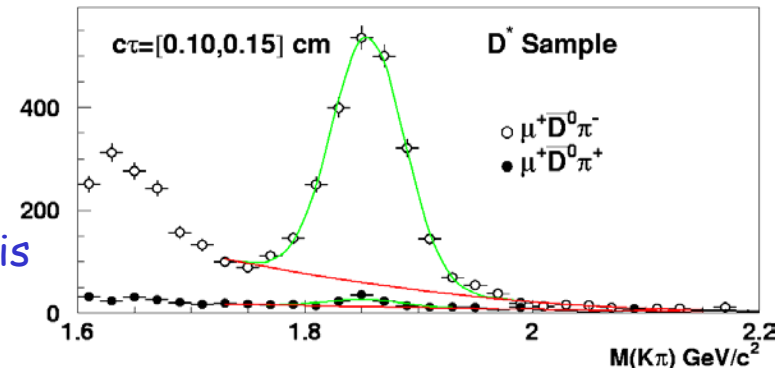
- **Additional inputs to the fit:**

  - sample compositions (previous slide)

  - K-factors (from simulation)

    $K = p_T(\mu D^0) / p_T(B)$ [separately for different (groups of) decay modes]

  - Relative reconstruction efficiencies for different decay modes B (from simulation)

  - Slow pion reconstruction efficiency [flat for $p_T(D^0) > 5$ GeV (one of our cuts)]

  - Decay length resolution (from simulation)

  - $\tau(B^+) = 1.674 \pm 0.018$ ps [PDG]

one example VPDL bin

DØ RunII Preliminary, Luminosity=250 pb^{-1}

$c\tau=[0.10,0.15]$ cm   D* Sample

$\circ\ \mu^+\overline{D^0}\pi^-$
$\bullet\ \mu^+ D^0\pi^+$

M(Kπ) GeV/c^2

D^0 Sample

$\circ\ \mu^+ K^+\pi^-$

M(Kπ) GeV/c^2

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Towards B$_s$ mixing

Trigger on opposite side muon which is used also for flavor tagging
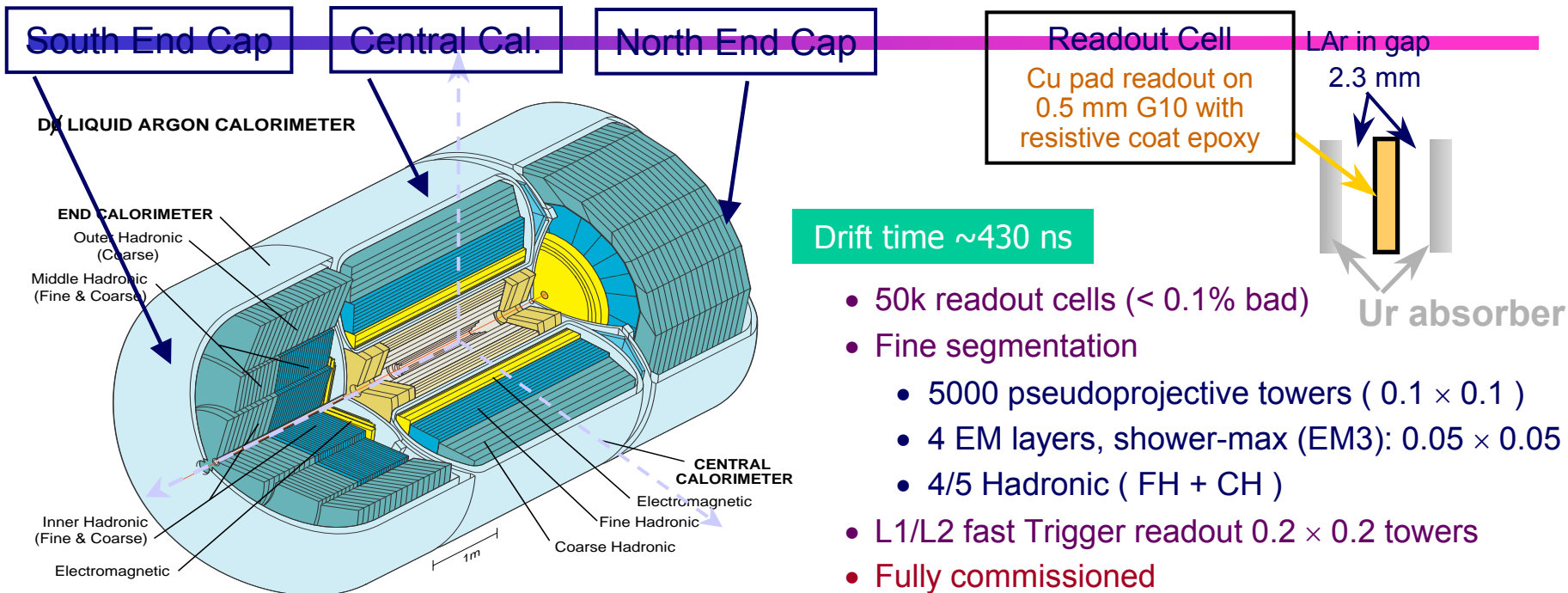
Therefore have access to

Fully reconstructed B$_s$ / B$_d$ hadronic decays:

- Poor statistics

- Excellent proper time resolution

- Need a few fb^{-1} of data
   to reach $\Delta m_s \cong 18$ ps^{-1}.

Calorimeters

Readout Cell
Cu pad readout on 0.5 mm G10 with resistive coat epoxy

LAr in gap 2.3 mm

Ur absorber

DØ LIQUID ARGON CALORIMETER

END CALORIMETER
Outer Hadronic (Coarse)
Middle Hadronic (Fine & Coarse)

Inner Hadronic (Fine & Coarse)

Electromagnetic

CENTRAL CALORIMETER
Electromagnetic
Fine Hadronic
Coarse Hadronic

1m

Drift time ~430 ns

- 50k readout cells (< 0.1% bad)
- Fine segmentation
  - 5000 pseudoprojective towers (0.1×0.1)
  - 4 EM layers, shower-max (EM3): 0.05×0.05
  - 4/5 Hadronic (FH + CH)
- L1/L2 fast Trigger readout 0.2×0.2 towers
- Fully commissioned

- **Liquid Argon sampling**
  - **uniform response, rad. hard, fine spatial segmentation**
  - **LAr purity important**
- **Uranium absorber (Cu/Steel CC/EC for coarse hadronic)**
  - **nearly compensating, dense $\Rightarrow$ compact**
- **Uniform, hermetic with full coverage**
  - **$|\eta| < 4.2$ ($\theta \approx 2^o$), $\lambda_{int} \sim 7.2$ (total)**
- **Single particle energy resolution**
  - **e: $\sigma/E = 15\% / \sqrt{E} \oplus 0.3\%$ π: $\sigma/E = 45\% / \sqrt{E} \oplus 4\%$**

MG
CH
OH
FH
ICD
MH
EM
EM
IH
FPS
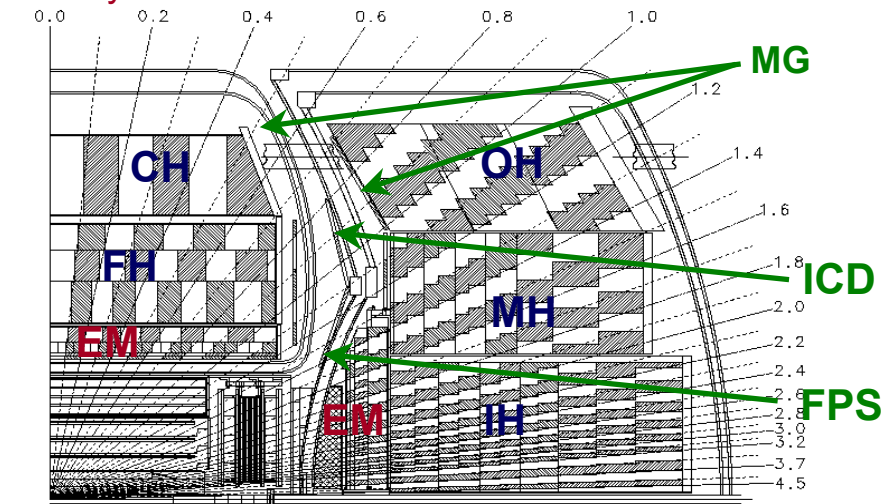
Jet Energy Scale Corrections
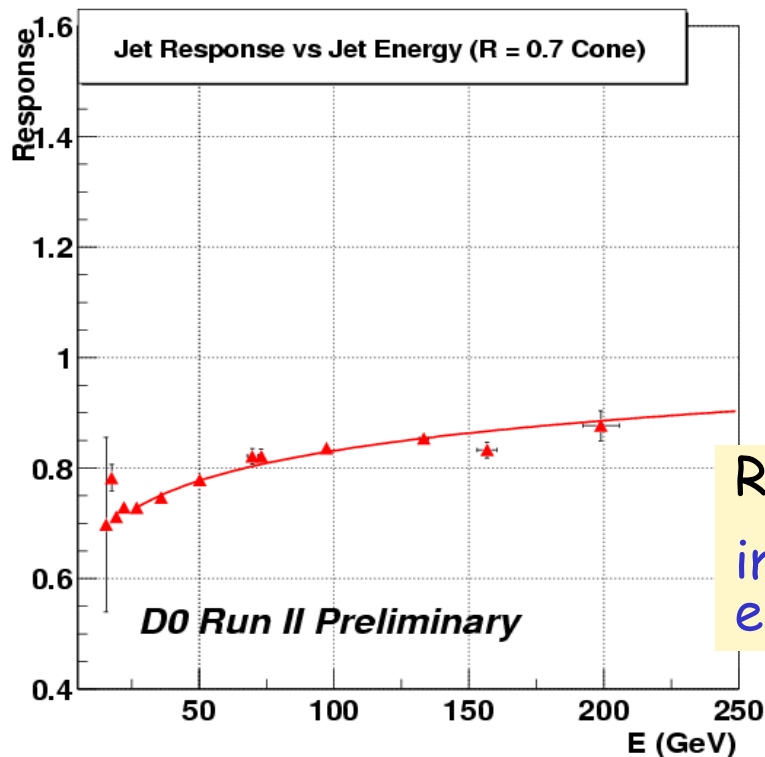
- Correct the measured energy:

$$E_{corr} = \frac{E_{meas} - E_O}{R_{jet} \, S_{cone}}$$

Offset: electronic noise, uranium noise, underlying event

zero bias and minimum bias events (data)

out of cone Showering:

energy density in ring around the jet axis (data)

Response: $E_{meas}/E_{deposit} \neq 1$

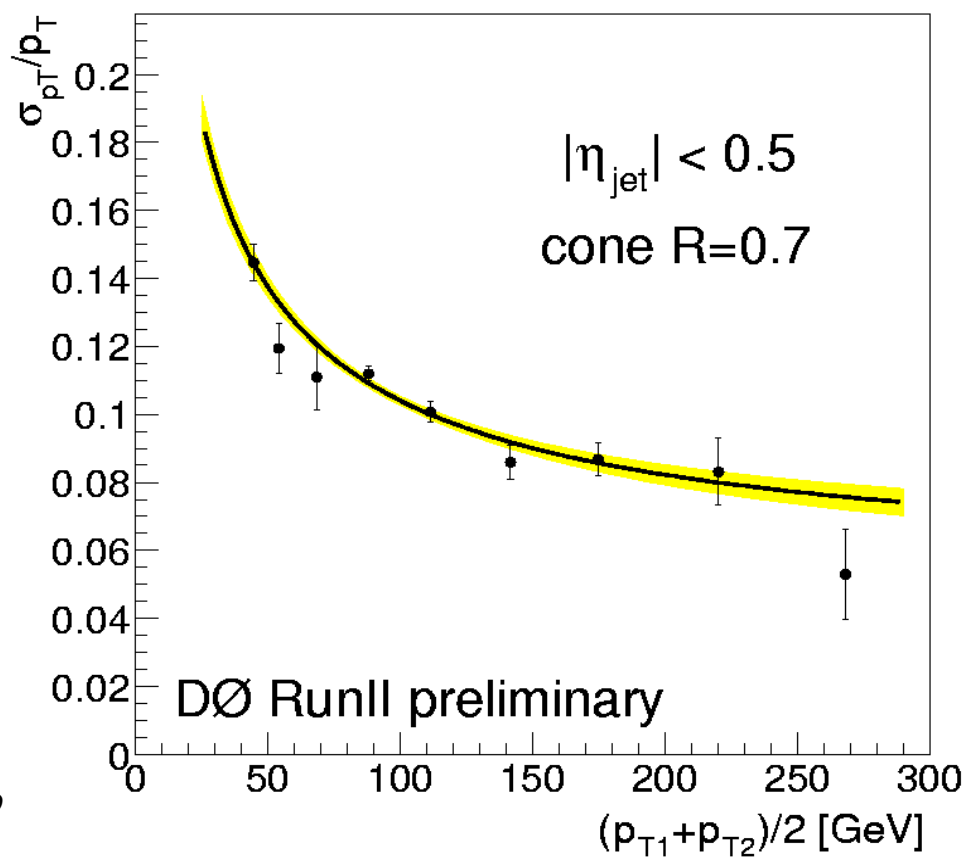imbalance energy in γ +jet events (data)

Jet Response vs Jet Energy (R = 0.7 Cone)

D0 Run II Preliminary

- Jet P_T resolution:

→ using energy asymmetry in dijet events

Jet p_T Resolution

$|\eta_{jet}| < 0.5$

cone R=0.7

DØ RunII preliminary

$(p_{T1}+p_{T2})/2$ [GeV]

$$A = \frac{p_T^{jet1} - p_T^{jet2}}{p_T^{jet1} + p_T^{jet2}} \qquad \frac{\sigma_{p_T}}{p_T} = \sqrt{2}\,\sigma_A$$

parametrized as:

$$\frac{\sigma_{p_T}}{p_T} = \sqrt{\frac{N^2}{P_t^2} + \frac{S^2}{P_t} + C^2}$$

N = 0.0 ± 2.2, S = 0.902 ± 0.045,
C = 0.052 ± 0.008

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